For Editorial Contents see page 71

PRINTED ON THIN PAPER FOR FOREIGN CIRCULATION.

Engineering Library

ENGINEERING:

An Illustrated Weekly Journal.

AUG 15 1940

EDITED BY CHAS. COOPER AND J. FOSTER PETREE.

TEMPORARY OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 18 & 20, COMPTON ROAD, HAYES, MIDDLESEX.

VOL. 150—No 3889. LONDON: FRIDAY, JULY 26, 1940. Registered at the General Post Office as a Newspaper PRICE 1s. BY FOREIGN POST 1s. 2½d.

Air Receivers Buoys, Road Wagons Tanks. **TANKS** Hoppers, Chimneys, Ducting.
EVERYTHING FROM MILD STEEL PLATE.
JOHN BELLAMY
EAST 1892 LIMITED, Est. 1860
MILLWALL E.14 1216

J. & E. HALL
REFRIGERATION
FOR LAND & MARINE PURPOSES
LIFTS AND ESCALATORS
J. & E. HALL LTD., ENGINEERS, DARTFORD, KENT.
Telephone: Dartford 3456.
London Office: 10, ST. SWITHINS LANE, E.C.4.
Telephone: MANSION HOUSE 9811. 755

PATTERNS
B. LEVY & CO. WOOD & METAL. Osbert St., S.W.1 Vic. 1073

METAL SLITTING SAWS
GROUND FLAT STOCK
WILLIAM WARD & SON (SHEFFIELD) LTD.
CENTENARY WORKS, WOODSEATS ROAD, SHEFFIELD. 712

SECTIONAL PRESSED STEEL TANKS
also
RIVETED and WELDED PLATEWORK
STORAGE TANKS, BUOYS, CHIMNEYS
BUNKERS, HOPPERS, Etc.
BROWN, LENOX & CO.
(LONDON) LIMITED.
Contractors to the Admiralty since 1808.
MILLWALL LONDON, E.14
Telephone: East 0700/1 830

TWIN DISC CLUTCHES
BRITISH TWIN DISC & CLARIFIERS LTD.,
BUSH HOUSE, ALDWYCH, LONDON, W.C.2

FOR HIGH CLASS
PATTERNS & MODELS
Phone: EUSton 3176 (4 lines)
GEORGE WAILES & CO. LTD.
382-8, EUSTON RD., LONDON, N.W.1.
Specialists since 1855 669

LOCOMOTIVES
STEAM OR DIESEL
HUDSWELL CLARKE & Co. LTD.
RAILWAY FOUNDRY, LEEDS.
London Office: 46, Victoria St., S.W.1.
Telephone: Victoria 1123 8559

SPENCER - BONECOURT
Patent Waste Heat Boilers
22, Farringdon Street, London, E.C.4. 869

YARROW
& CO. LTD.,
GLASGOW
SHIPBUILDERS
MARINE ENGINEERS 848
LAND AND MARINE BOILER MAKERS

PETER BROTHERHOOD
PETERBOROUGH LTD.
STEAM ENGINES AND TURBINES,
GAS AND OIL ENGINES,
AIR COMPRESSORS,
REFRIGERATING PLANT.
See advertisement, Page 27 6938

SPRINGS
FOR ALL PURPOSES
WILLFORD & CO. LTD., 688
PARK HOUSE WORKS, SHEFFIELD, 9

DREDGERS
OF ALL TYPES
FERGUSON BROS. (Port-Glasgow) LTD.
PORT-GLASGOW. 1098

FORGINGS.
WALTER SOMERS, LTD.,
HALESOWEN 7116

WAGONS
HURST, NELSON & CO., LTD.,
MOTHERWELL 3382

SPECIAL MACHINES
MADE TO ORDER
Parts and repairs
Erection of Plant
Millwrights work 952
THOMAS HUNT & SONS
Bridge Road West BATTERSEA, S.W.11.

WATER SOFTENING
PATERSON ENGINEERING CO., LTD.,
83, KINGSWAY, LONDON 780

For Sale as Going Concern.
SMALL FULLY-EQUIPPED ENGINEERING WORKS—MIDLAND TOWN. Turnover £11,000. Very profitable business. Now engaged on export trade and munitions. Plenty of orders on hand.—Apply to M. P. FERNEYHOUGH & CO., 6, Commerce Street, Longton, Stoke-on-Trent. K 650

Research Engineers, Ltd.,
Northampton Grove, Canonbury, London, N.1. Design and construction of mechanical and electrical machinery and apparatus. Experimental work of any description. We specialise in scale working models of large machines and structures for exhibitions and travellers' use. 794

BABCOCK

RAPIER
Builders of Europe's Largest
EXCAVATORS
RANSOMES & RAPIER, LTD
IPSWICH 1016 ENGLAND

CRADLEY BOILERS
CRADLEY BOILER CO., LTD., 1088
CRADLEY HEATH, STAFFS.

MUREX
Electrodes
1107
MUREX WELDING PROCESSES LTD.,
HERTFORD RD., WALTHAM CROSS, HERTS.

MACROME treated
TOOLS do more
work in less time
MACROME
LIMITED
Z Dept., HAY MILLS, B'HAM ENG
Phone: VIC. 1283-4.

CRANES
GEORGE RUSSELL & CO., LTD.,
Motherwell. 816

GEARING
BARRY, HENRY & COOK, LTD.
789

Trepanning machine for tube plates, three 3½ in. spindles. Admits plates 10 ft. 6 in. by 8 ft. 6 in. Table size, 8 ft. 6 in. by 7 ft. Traverse, 8 ft. CH. seat for motor. Makers, Campbells & Hunter.—Apply Danks of Netherton, Ltd., Netherton, Dudley, Worcs. J 292

Slat or Belt Conveyor to handle bales 2 ft. 0 in. wide by 3 ft. 0 in. Length, 50-55 ft. centres. Receiving end 3 ft. above ground; delivery 20 ft. above ground.
BALE ELEVATOR, 4 ft. 0 in. to 5 ft. 0 in. wide. Arranged vertically or with slight inclination. Height between reception and delivery points 18 ft.—Write, giving full particulars, to K 651, Offices of ENGINEERING.

Alfred Herbert Ltd., Coventry
PAY BEST PRICES for SECONDHAND MACHINE TOOLS in good condition, by first-class makers.—Write, wire, or phone, and our representative will call. 'Phone 88781 Coventry. Telegrams LATHE, Coventry. W 205

VALVE

On Active Service
COOPER
SPLIT ROLLER BEARINGS
KING'S LYNN 708 NORFOLK

LIGHTALLOYS LTD.
FIRST QUALITY
ALUMINIUM CASTINGS
ALPAX WORKS, St. Leonard's Road, Willesden Junction, London, N.W.10. Telephone: Willesden 3460-1-2. Telegrams: "Lightalloys-Phone-London."

WATER SOFTENERS
JOHN THOMPSON
(KENNICOTT WATER SOFTENERS) LTD.,
WOLVERHAMPTON
Estd. over 40 years. 744

TAYLOR AND CHALLEN POWER PRESSES
TAYLOR AND CHALLEN LIMITED. 718
DERWENT WORKS, BIRMINGHAM, 19.

VISCO
AIR FILTERS
DUST COLLECTORS
COOLING TOWERS 1128
THE VISCO ENGINEERING CO., LTD.,
Stafford Road, Croydon. Phone: Croydon 4181/5

SAMUEL PLATT
LIMITED
King's Hill Foundry, Wednesbury, Staffs.
DRAWBENCHES
FOR 689
AIRCRAFT WORK

ALLDAYS & ONIONS
665 BIRMINGHAM. LTD.
HAMMERS PNEUMATIC & STEAM

"The machine with a BRAIN"
SCIAKY
SPOT WELDERS
SLOUGH —— 22342

WATER TURBINES
GILBERT GILKES & GORDON LTD.,
KENDAL, ENGLAND. 787

VALUE 866

JULY 26, 1940. —— ENGINEERING. —— VOL. 150 PAGES 61—80

FIELDING
HYDRAULIC PRESSES & PUMPS

- **EXTENSIVE RANGE**
  VERTICAL & HORIZONTAL TYPES 500 H.P. & OVER
- **RIGIDITY & STRENGTH**
  DESIGN BASED ON EXPERIENCE. SOLID FORGINGS
- **SPECIAL MATERIALS**
  VALVES & RAMS ALLOY STEEL SPECIALLY TREATED
- **REDUCTION GEAR**
  TOTALLY ENCLOSED DOUBLE HELICAL TYPE
- **TOTALLY ENCLOSED**
  REMOVABLE INSPECTION COVERS. LOW MAINTENANCE
- **FORCED LUBRICATION**
  DRILLED CRANKSHAFT & CONNECTING RODS
- **BEARINGS & JOURNALS**
  WHITE METAL LINED ADJUSTABLE FOR WEAR
- **RELIABILITY**
  COMPONENTS DESIGNED FOR SERVICE & MAINTENANCE

FIELDING & PLATT LTD., GLOUCESTER

CREEP UNDER COMBINED TENSION AND TORSION.

PART I.—THE BEHAVIOUR OF A 0·17 PER CENT. CARBON STEEL AT 455 DEG. C.

By H. J. TAPSELL, A.C.G.I., A.M.I.Mech.E., and A. E. JOHNSON, M.Sc.

(*Continued from page* 25.)

Results.—Curves of the axial and circumferential creep strains with time over a testing period of 150 hours for each test were found in all cases to similar. It should be pointed out that the scale of the mean curve is closely that of the torsion test at 4·92 tons per square inch, which gave the largest strain of all creep tests. Errors in tests giving smaller strains are considerably magnified in Fig. 10. Figs. 11 to 13, herewith, and Fig. 14, on page 63, show the curves obtained for a few tests. They fit the experimental points very well in these and in all cases. Fig. 11 shows the strain-time curves for pure-tension tests; Fig. 12, the strain-time curves for the stress ratio $\frac{s}{t} = 0{\cdot}172$; Fig. 13, the strain-time curves for the stress ratio $\frac{s}{t} = 2{\cdot}0$; and Fig. 14, the strain-time curves for pure torsion tests.

Fig. 10.

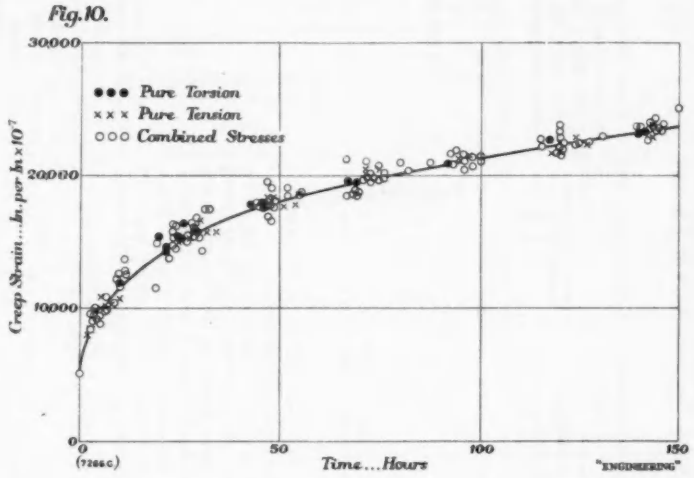


Fig. 11.

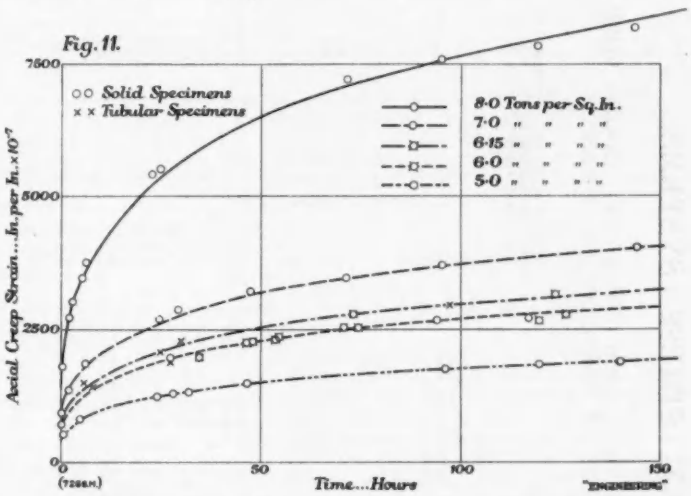


Fig. 12.

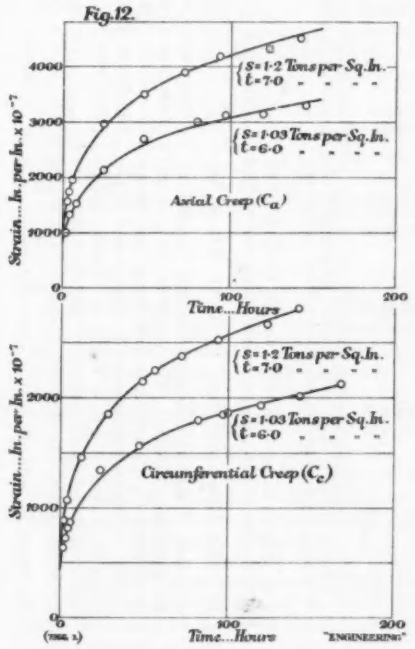
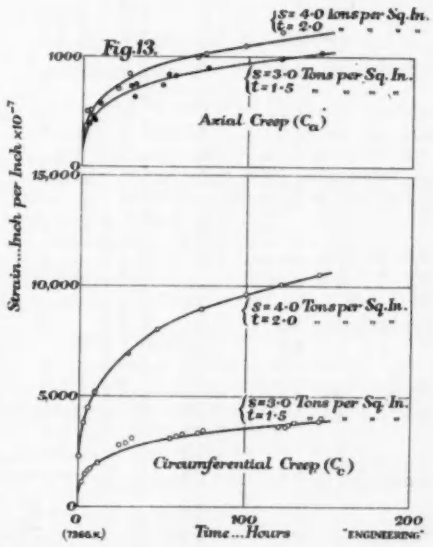


Fig. 13.



have the same geometric form. To determine this common form as precisely as possible, a comparison of the curves was made by plotting all the results on one diagram as in Fig. 10, on this page, which shows the characteristic curve form for strain-time curves. Since the creep readings in the torsion tests were less affected by temperature variations than those in the other tests, the mean form of the curves for the pure torsion tests was first ascertained and plotted to a scale equivalent to that of the creep curve for the highest torsion stress. The creep readings for each of the other tests were plotted to increased scales of suitable magnitude to make the enhanced readings of each individual test fit the mean curve as closely as possible. The common curve form for all the tests was then drawn through the points as shown in Fig. 10. All the curves drawn for the individual tests were derived from the common curve in Fig. 10 by appropriate reduction of scale and were, therefore, geometrically

The creep-curve form is such that the creep rate varies with time as follows:—

Period of test, hours ...	150	25	10
Ratio of rate of creep to that at 150 hours	1·0	3·33	7·08

Table I, on page 62, gives the experimental values for the axial and the circumferential creep rates at 150 hours in the several tests. The experimental values of the principal creep rates (C_1, C_2 and C_3) in Table I have been computed for a test period of 150 hours, making use of the equations given earlier in the paper. The principal creep rates at periods of 10 hours and 25 hours are related to those at 150 hours in the ratios given above.

It will be seen that no axial creep took place in the pure torsion creep tests. This, in the author's opinion, offers strong evidence that the creep on a plane is unaffected by the stress acting normally to it. If it had been possible to show that a hydrostatic stress makes no difference to the creep of a stress system for this material the evidence would be conclusive, but since the authors' work was inherently incapable of providing this additional evidence the conclusion must be tentative. Except in the case of one test, the creep in the direction of wall thickness, C_3, is negative, this being in general agreement with Bailey's results on steels. The one exception occurs in the test in which the torsion stress was high at 4 tons per square inch and the $\frac{s}{t}$ ratio was equal to 2·0. It should be mentioned that C_2 is obtained from the relation $C_3 = -(C_1 + C_2)$, and if C_3 is small, slight experimental errors in C_a and C_c would give rise to a much larger error in the deduced value of C_3 and might alter its sign.

The relation between log. tensile stress and log. axial creep rate in the pure tension tests is shown in Fig. 15, on page 63. Over a range of stress not including the highest and lowest values of applied stresses, the relationship is reasonably linear and can be expressed in the form

$$\text{Creep rate } (C_a) = A\,(\text{Stress})^n,$$

where n has a value of 2·2 and is independent of the time at which the creep rate is measured. The constant A varies with the time. It was considered that a similar relationship to the above would probably be applicable in correlating the creep rates in the direction of principal stress with whatever stress function is the determining factor of creep under combined stress conditions, the relation being as follows:—

$$\text{Creep rate in the direction of principal stress} = K\,(\text{Stress function})^n,$$

where K may be a complex function embodying the time at which the creep rate is measured and possibly a factor associated with strain energy. Initially, it was assumed that the exponent n would have a constant value of 2·2 for any of the stress conditions imposed in the tests. Thus, the authors' analysis of the experimental data may be said to involve the determination of the nature of the factor K, the stress function, and the exponent n.

Consideration of Results in Relation to Various Theories.—A summary of the theories of creep under combined stress put forward by Odqvist, Bailey, Kanter, Soderberg, Marin, and Nadai, is given in Appendix II, which also shows how these theories have been adapted to enable them to be compared on a theoretical basis, and to be considered in relation to the experimental results. These theories, with the exception of that of Odqvist, conform in general to the relationship given above. In the equations of Bailey, Marin and Soderberg, the factor K represents a function of the strain energy. The factor K, in the equations of Kanter and Nadai, represents some function of the "viscosity" of the material. For the stress function, Soderberg, Marin, Kanter and Nadai, adopt the difference of the maximum shear stresses, whilst Bailey adopts the difference of the n^{th} powers of the maximum shear stresses. The expressions for the creep rates in the direction of major principal stress, derived from the various theories, in the

CREEP OF STEEL UNDER COMPLEX STRESS SYSTEMS.

TABLE I.—RESULTS OF PURE TENSION, PURE TORSION, AND COMBINED-STRESS CREEP TESTS ON 0·17 PER CENT. CARBON STEEL AT 455 DEG. C., WITH VALUES COMPUTED FROM VARIOUS THEORIES. VALUES AT PERIOD OF 150 HOURS.*

Tension Stress, t tons per sq. in.	Torsion Stress, s tons per sq. in.	Stress Ratio, $\frac{s}{t}$	Measured Axial Creep Rate, in. per in. per hour × 10⁻⁶ C_a.	Measured Circumferential Creep Rate, in. per in. per hour × 10⁻⁶ C_c.	Principal Creep Rates from Experiment and Theory, using a Value of $n = 2{\cdot}2$. N.P.L. (Experimental), in. per in. per hour × 10⁻⁶. C_1	C_2	C_3	Odqvist's Theory, in. per in. per hour × 10⁻⁶. C_1	C_2	C_3	Bailey's Theory, in. per in. per hour × 10⁻⁶. C_1	C_2	C_3	Theories of Soderberg and Marin, in. per in. per hour × 10⁻⁶. C_1	C_2	C_3	Values of k_1, k_2 and k_3 computed from Experimental Results, using a Constant Value of $n = 2{\cdot}2$. k_1 × 10⁻⁷	k_2 × 10⁻⁷	k_3 × 10⁻⁷	Values of k_2 and k_3 for Values of n as stated, which make k_1 Constant at 2·1 × 10⁻⁷. n	k_2 × 10⁻⁷	k_3 × 10⁻⁷
8·0†	—	0	1·70	—													2·1	2·1	2·1	2·2		
7·0†	—	0	0·82	—	0·82	−0·41	−0·41										2·2	2·2	2·2	2·2		
6·15	—	0	0·66	—	0·66	−0·33	−0·33										2·1	2·1	2·1	2·2	2·1 (mean value)	2·1 (mean value)
6·0†	—	0	0·61	—	0·61	−0·31	−0·31															
6·0	—	0	0·60	—	0·60	−0·30	−0·30															
5·0†	—	0	0·40	—	0·40	−0·20	−0·20										2·1	2·1	2·1	2·2		
4·0†	—	0	0·18	—	0·18	−0·09	−0·09															
7·0	1·2	0·172	0·94	0·58	0·99	−0·80	−0·19	0·95	−0·49	−0·46	0·95	−0·49	−0·46	0·96	−0·50	−0·46	2·2	3·5	0·85	2·22	3·3	0·85
6·0	1·03	0·172	0·69	0·42	0·72	−0·57	−0·15	0·68	−0·37	−0·31	0·68	−0·35	−0·33	0·68	−0·36	−0·32	2·3	3·5	1·0	2·24	3·2	0·9
5·0	2·5	0·5	0·94	0·47	1·04	0·37	−1·41	0·76	−0·47	−0·29	0·76	−0·45	−0·31	0·77	−0·48	−0·29	3·1	1·7	9·0	2·37	1·2	6·7
6·2	3·1	0·5	1·47	1·42	1·76	−0·24	−1·52	1·22	−0·76	−0·46	1·22	−0·73	−0·49	1·17	−0·72	−0·45	2·9	0·7	6·5	2·37	0·5	4·6
3·0	3·0	1·0	0·49	0·86	0·75	−0·21	−0·54	0·60	−0·44	−0·16	0·59	−0·42	−0·17	0·60	−0·44	−0·16	2·8	$1·0_5$	6·7	2·34	$0·8_5$	5·3
2·5	2·5	1·0	0·38	0·28	0·47	0·15	−0·62	0·40	−0·30	−0·10	0·39	−0·28	−0·11	0·40	−0·30	−0·10	2·6	1·1	11·4	2·32	$0·9_5$	9·7
1·53	2·9	1·9	0·21	0·80	0·52	−0·30	−0·22	0·44	−0·36	−0·08	0·42	−0·35	−0·07	0·43	−0·36	−0·07	2·7	1·9	3·2	2·33	1·5	5·0
2·0	4·0	2·0	0·25	2·15	1·09	−1·13	0·04	0·86	−0·75	−0·11	0·84	−0·70	−0·14	0·86	−0·73	−0·13	2·7	3·4	0·3	2·33	2·6	0·5
—	2·95	∞	—	0·67	0·34	−0·34	0	0·38	−0·38	0	0·36	−0·36	0	0·37	−0·37	0	1·8	1·8	0	2·16	2·1 (mean value)	0
—	3·86	∞	—	1·15	0·58	−0·58	0	0·69	−0·69	0	0·66	−0·66	0	0·68	−0·68	0	2·0	2·0	0	2·16		
—	4·92	∞	—	4·73																		

* Rates for other periods may be obtained by multiplying 150-hour rates by suitable factors—7·08 at 10 hours, 3·33 at 25 hours.
† Solid specimen; all others are tubular.

manner shown in Appendix II, are as follows :—

Odqvist :

$$C_1 = \frac{C_a}{4}\left\{3\left[\sqrt{1+\left(\frac{2s}{t}\right)^2}\right]+1\right\} = \frac{C_c}{4}\left\{3\left[\sqrt{1+\left(\frac{2s}{t}\right)^2}\right]+1\right\}\times\frac{t}{3s}$$

where C_a and C_c are axial and circumferential creep rates, respectively.

Bailey :

$$C_1 = \frac{A}{2}\left[\tfrac{1}{2}(p_1-p_2)^2+\tfrac{1}{2}p_1^2+\tfrac{1}{2}p_2^2\right]^m\left[(p_1-p_2)^{n-2m}+p_1{}^{n-2m}\right]$$

Kanter :

$$C_1 = \frac{1}{\phi_1}(2p_1-p_2)\,e^{C(2p_1-p_2)}$$

where ϕ_1 is a function of "initial viscosity" and C is a constant.

Soderberg, Marin :

$$C_1 = \frac{A}{2\left(\frac{n+1}{2}\right)}\left[\Sigma(p_1-p_2)^2\right]^{\frac{n-1}{2}}[2p_1-p_2]$$

Nadai :

$$C_1 = \frac{2p_1-p_2}{6\zeta}$$

where ζ is a function related to "viscosity."

TABLE II.—COMPARISON OF EXPERIMENTAL VALUES OF AXIAL AND CIRCUMFERENTIAL CREEP RATES WITH THOSE COMPUTED ON THE BASIS OF THE VARIOUS THEORIES.

t, t per sq. in.	s, t per sq. in.	Experiment. C_a.	Experiment. C_c.	Theory of Odqvist.* C_a.	Theory of Odqvist.* C_c.	Theory of Bailey.† C_a.	Theory of Bailey.† C_c.	Theories of Soderberg and Marin.† C_a.	Theories of Soderberg and Marin.† C_c.
		in. per in. per hr. × 10⁻⁶.		in. per in. per hr. × 10⁻⁶.		in. per in. per hr. × 10⁻⁶.		in. per in. per hr. × 10⁻⁶.	
2·5	2·5	0·38	0·28	0·21	0·63	0·20	0·59	0·21	0·62
5·0	2·5	0·94	0·47	0·58	0·87	0·58	0·86	0·59	0·88
2·0	4·0	0·25	2·15	0·26	1·56	0·25	1·49	0·26	1·54
6·0	1·03	0·69	0·42	0·65	0·34	0·66	0·34	0·66	0·34

* Values computed directly from Odqvist's equations for axial and circumferential creep rates.
† Values derived by means of the relations between axial, circumferential and principal creep rates, from values of principal creep rates computed from the formulæ of Bailey, Soderberg and Marin.

It follows from Odqvist's theory that the ratio of the axial to the circumferential creep rate should be equal to $\frac{t}{3s}$, and that the creep rate in the direction of wall thickness (C_2) should be one-half the axial creep rate (C_a). The values of the principal creep rates C_1, C_2 and C_3 derived from this theory for the several combinations of t and s used in the experiment are given in Table I. Values of C_a and C_c deduced from Odqvist's equation above are given in Table II, and the comparison between the ratio $\frac{C_a}{C_c}$ and Odqvist's criterion ratio $\frac{t}{3s}$ is given in Table III. From these tables it will be seen that the theoretical criteria of Odqvist are not fulfilled by the experimental results.

In Bailey's theory, the expression for the creep rate, C_1, involves the product of the shear strain energy raised to some power, m, and the difference of the maximum shear stresses raised to the power $(n-2m)$. On the basis of Bailey's theory it can be shown that the ratio of the major principal creep rates under corresponding tension and torsion stress systems (*i.e.*, where $s = \frac{t}{2}$) is as follows :—

$$\text{Ratio} = \frac{2}{\left(\frac{3}{4}\right)^m\left[1+\left(\frac{1}{2}\right)^{n-2m}\right]} = \text{R (say).}$$

From the experimental results it is found that R has the value of $1{\cdot}7_4$ and is independent of the time of the test. Taking the value of $n = 2{\cdot}2$ in the above ratio, the maximum value of R is $1{\cdot}6_8$ and occurs for a value of m between 0 and 0·3. A value of $m = 0$ is the most rational value to adopt in view of the experimental results, which means that the strain-energy function disappears. Further, it may be noted that the dimensions of the stress function must be those for the case of pure tension, namely, (stress function)$^{2\cdot2}$, and if a strain-energy function even of unit power be introduced, its

TABLE III.—*Examination of Odqvist's Theoretical Criterion for the Creep of a 0·17 per cent. Carbon Steel at 455 deg. C.*

In this theory the criterion is $\frac{C_a}{C_c} = \frac{t}{3s}$.

Tension Stress t	Torsion Stress s.	Ratio $\frac{t}{3s}$.	Ratio $\frac{C_a}{C_c}$ at all periods of test.
7·0	1·2	1·94	0·54
6·0	1·03	1·94	0·55
5·0	2·5	0·67	0·67
6·2	3·1	0·67	0·34
3·0	3·0	0·33	0·19
2·5	2·5	0·33	0·45
1·53	2·9	0·17	0·89
2·0	4·0	0·17	0·39

CREEP UNDER COMPLEX STRESS SYSTEMS.

Fig. 14.

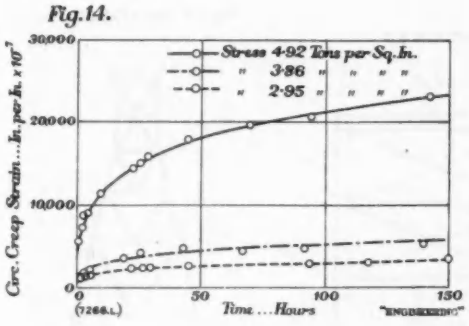


Fig. 15.

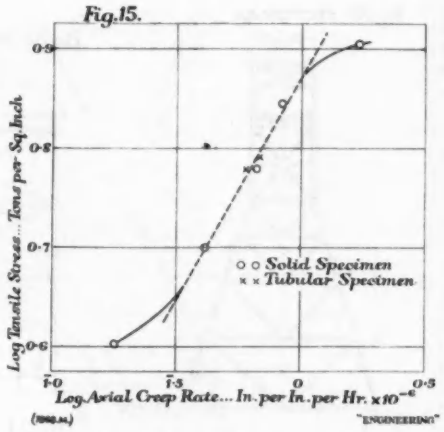
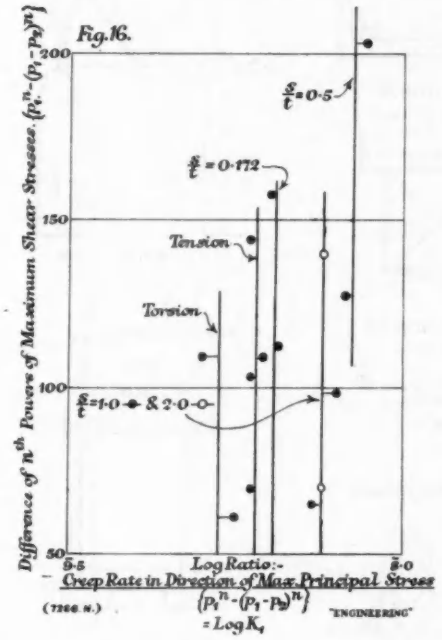


Fig. 16.



dimensions being (stress)², the power of the shear-stress factor would be only 0·2. This would mean that creep was mainly due to shear-strain energy and almost independent of the shear stresses in the planes where shear contributes to creep in the directions concerned. It is felt that the experimental results provide ample reason for excluding the strain-energy factor.

The results given in Table I for the principal creep rates according to Bailey's theory are, therefore, based on simplified expressions, the strain energy function being excluded and the stress function raised to the n^{th} power, where n is the exponent in the tensile creep relation — creep rate = A (stress)^n. In Bailey's theory, the value of A is assumed to remain constant for all stress combinations. As may be seen from Table I, the simplified expressions do not lead to values of creep rates in conformity with the experimental data. As shown in Appendix II, the theories of both Soderberg and Marin lead to an identical expression for C_1 as given above. This expression contains a strain-energy function and a stress function consisting of the plain difference of the maximum shear stress instead of some power of the difference, as suggested by Bailey. The constant A has the same significance as in Bailey's theory, that is, it is derived from tensile creep test data and is assumed to be a definite constant for all stress combinations. Table I shows that the creep rates computed on the basis of the theories of Soderberg and of Marin differ from the experimental results in roughly the same degree as those of Bailey and Odqvist. Both Kanter and Nadai suggest that the stress function involved is the plain difference of the maximum shear stresses.

Consideration of the experimental results led the authors to believe that the plain difference of the maximum shear stresses was not a satisfactory stress function, and, as already stated, it was thought that the principal creep rates could be expressed in the form

$$C_1 = K_1[(p_1 - p_2)^n - p_1^n]$$
$$C_2 = K_2[p_2^n - (p_1 - p_2)^n]$$
$$C_3 = K_3[-p_1^n - p_2^n]$$

The difference of the n^{th} powers ($n = 2{\cdot}2$) of the maximum shear stresses are plotted against the log. of the ratio of the maximum principal creep rate (C_1 at 150 hours) to the difference of the n^{th} powers of the maximum shear stresses in Fig. 16, on this page. From this figure, which shows the value of K_1 for different ratios of $\frac{s}{t}$ ($n = 2{\cdot}2$), it will be seen that K_1 is practically constant for each particular ratio of $\frac{s}{t}$, but varies somewhat with the value of $\frac{s}{t}$. Clearly, K_1 must also depend on the time T at which the creep rate C_1 is determined, that is, on the form of the creep curve. By trial it is found, for the particular test material and temperature involved, that $K_1 = k_1 T^{-0.71}$, where k_1 is independent of time. Values of k_1, k_2 and k_3 for the case where n is equal to 2·2 are given in Table I. It is evident that k_1 is not strictly constant but varies between $1{\cdot}9 \times 10^{-7}$ and $3{\cdot}0 \times 10^{-7}$. However, for each particular value of $\frac{s}{t}$, k_1 has a reasonably constant value, which confirms that it is not a function of strain energy. The values of k_2, and particularly k_3 (for the case where $n = 2{\cdot}2$) differ from, and vary much more than, k_1. There is evidence that k_2 should be constant for each particular value of $\frac{s}{t}$, and probably k_3 should be similarly constant.

It was thought that k_1 should have a constant value for all stress combinations, providing the value of n in the expression $C_1 = k_1$ (stress function)^n remains constant. By referring to Fig. 15 it will be seen that the creep rate in the pure tension tests can only be expressed in the above form within a narrow range of stress. It is very probable that this characteristic curve has a continuous change of curvature over the whole range of stress. Moreover, the characteristic curves for each combination of $\frac{s}{t}$, though identical in form, would be displaced relatively with respect to the log. stress — log. creep rate axes. For these reasons, it would be almost impossible to choose arbitrary ranges of stress for all stress combinations which would provide constant values of k_1 and n. Thus, the values of k_1 and n in these experiments may be expected to vary slightly, the variation of n being the more important. In the last columns of Table I, values of k_1, k_2 and k_3 are given for the case where n is assumed to vary as indicated and in such manner that k_1 has a constant value of $2{\cdot}1 \times 10^{-7}$, that is, the value in the pure tension tests. The variation of n is very small and is consistent with the view that the characteristic curve is probably not linear. Although k_1 should vary if n does, such variation is negligible.

The results in Table I provide strong evidence that the creep rate in the direction of major principal stress is proportional to the difference of the n^{th} powers of the maximum shear stresses. It is thought that the same stress function applies in regard to the other principal creep rates, but the differences between the distribution of secondary and wall-thickness creep rate from one stress system to another, as indicated by the constants k_2 and k_3, appear to be fundamental. The general trend of the results suggests that creep in the direction of wall thickness, C_3, increases at the expense of the creep in the direction of the secondary principal stress, C_2, reaching a maximum between $\frac{s}{t} = 0{\cdot}5$ and $\frac{s}{t} = 1$, and then decreases, becoming zero for the case of pure torsion. There are exceptions to this trend, particularly in the test for which $t = 2$, $s = 4$, where, apparently, the torsion stress is high enough to cause a circumferential-creep rate which lies outside the linear portion of the log. stress-log. creep rate relation. It is hoped that the further investigations in view will provide more evidence on these points.

(To be continued.)

LITERATURE.

Physico-Chemical Methods. By PROFESSORS JOSEPH REILLY and WILLIAM NORMAN RAE. Two vols. London: Methuen and Company, Limited. [Price 84*s.*]

SINCE this book was first published in 1926 as a single volume, it has developed into two enlarged and revised editions, the latest of which is issued in two volumes at the price of four guineas, compared with 30*s.* for the first edition. It is a painstaking compilation, surveying a very extensive selection of the methods used in the ever-widening field of physical chemistry; but, while the number of pages has increased from 735 to 1,266, it may be observed that the cost per page has nearly doubled—a circumstance which, in the present difficult times, encourages a tendency to inquire whether the greater bulk and considerably greater cost are really justified. The first volume is devoted to "Measurement and Manipulation," including basic measurement and units, observation and calculations, apparatus, pumps, high-pressure technique, thermometry and thermo-chemistry, molecular properties, etc. The second volume deals with "Physical Properties," and covers gases and vapours, colloids, distillation, separation, electrochemistry, optical methods, hydrogen-ion concentration, dielectrics, radioactivity, etc. The space allocation appears in some cases to be a little disproportionate; for example, 65 pages are devoted to distillation, but only one-fifth of this space to gas analysis. Thermionic vacuum tubes occupy 17 pages, but molecular properties extend to 80 pages—though it is fair to state that the scope is wide, ranging from solubility and molecular weights to the stability of explosives.

The apparent disproportion in treatment is noticeable also in considering specific items; especially in view of the authors' statement that the book is intended for the chemist and therefore, by implication, not particularly for the student. If so, there seems hardly sufficient justification for including drawings of pipettes and a description of the purposes for which they are "mostly employed," for the elementary notes on the microscope and on photography, or for the illustrations of the vernier, the slide rule, the balance (with six illustrations of one maker's products) and the seemingly inevitable box of weights. The authors claim to have resisted the temptation to make the work an unwieldy encyclopædia, but they have permitted, in such items as these, an accretion of elementary detail for which a heavy price has been paid in space that might have been better employed—for example, in extending the sections on radioactivity and the viscosity of liquids, neither of which, at present, will add much to the equipment of a trained chemist.

These criticisms are made because it had been hoped that the new edition would provide not merely a substitute for, but a definite improvement on the obscure Teutonic publications which have

irritated technical workers for so many years, and because it is felt that the authors have all the qualifications, as well as the industry, requisite for the production of a successful reference book of this kind. As it is (with the exception of the elementary matter mentioned), they could hardly have done more in the space available. If, however, our imagined ideal is to be realised, it will be necessary to decide more definitely for which audience the book is to be designed: whether for the student (who can rarely afford such a price as four guineas) or for the practising industrial chemist who, as a rule, is rather more critical and better informed than is commonly realised.

Internal-Combustion Engines. By PROFESSOR LESTER C. LICHTY. 5th edition. London: McGraw-Hill Publishing Company, Limited. [Price 30*s.*]

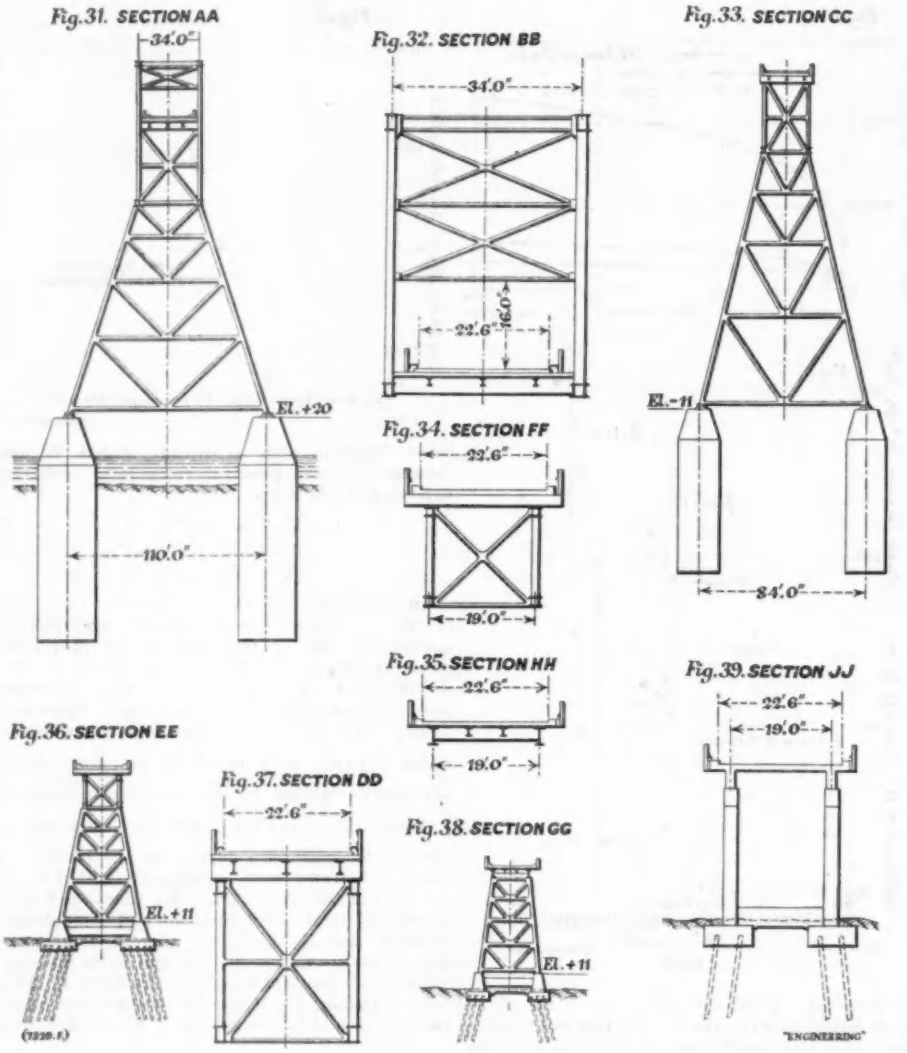
"REVISING" a textbook dealing with a rapidly-developing subject has much in common with the process of "rebuilding" as practised in railway locomotive shops: the "revised" or "rebuilt" product still consists of a certain assortment of typical components, arranged more or less as before, but of the original locomotive there may remain in course of time little more than the nameplate, and, of the book, not much except the title. This is directly applicable to the present work, which has changed even its author, the original edition of 1915 having been written by the late Mr. Robert L. Streeter. Professor Lichty's function was rather that of editor in connection with the editions of 1929 and 1933, but he now appears as author of what is virtually a new book.

It is comparatively rare to find theory and practical application satisfactorily combined in one volume, where internal-combustion engines are concerned, but in this case the author does succeed to a considerable extent in establishing definite links. Having analysed the theoretical processes of the internal-combustion engine and the combustion of fuels, he proceeds to discuss the actual deviations from the ideal process in a separate chapter, in which liberal references are provided to the experimental work recorded in university research reports and in the technical Press. The treatment of carburation and fuel injection provides another good example of the method of illustrating principles by means of the latest available research results on the effect, for instance, of altitude, filter restrictions and the lay-out of induction systems. There is a tendency, perhaps, to attempt rather too much within the limits of a single volume; the concluding three chapters, on the mechanics of moving parts, vibration and balance, and engine design, might well be amplified to form a second.

Applied Economics for Engineers. By BERNARD LESTER. New York: John Wiley and Sons, Inc. London: Chapman and Hall, Limited. [Price 24*s.* net.]

SINCE the study of economics has become recognised as a proper and, indeed, a necessary item in an engineering curriculum, there have been many books published, dealing with various aspects of this many-sided subject. There have been few, however, which kept so well in mind, as does this volume by Mr. Lester, the essential requirement that such a work, to be regarded as satisfactory, must "provide the student in engineering with an introduction to the practical aspects of economics, basing this upon conditions and problems which he is likely to encounter in practice." To what extent this may be the result of the closer liaison in the United States than in this country between educational establishments and industry is perhaps, a moot point; and it may be that the examples given—which, of course, are predominantly American—will not prove wholly satisfying to the English reader. The basic principles, however, are not greatly affected by national boundaries or political considerations, and the reader who thoroughly absorbs those principles should find no difficulty in applying them to the circumstances within the range of his own observation or in supplementing them from his own experience. A minor criticism might be made, that many of the illustrative examples cited would be better incorporated in the text instead of being given as footnotes.

THE PORT ARTHUR-ORANGE BRIDGE, TEXAS.



THE PORT ARTHUR-ORANGE BRIDGE, TEXAS, U.S.A.

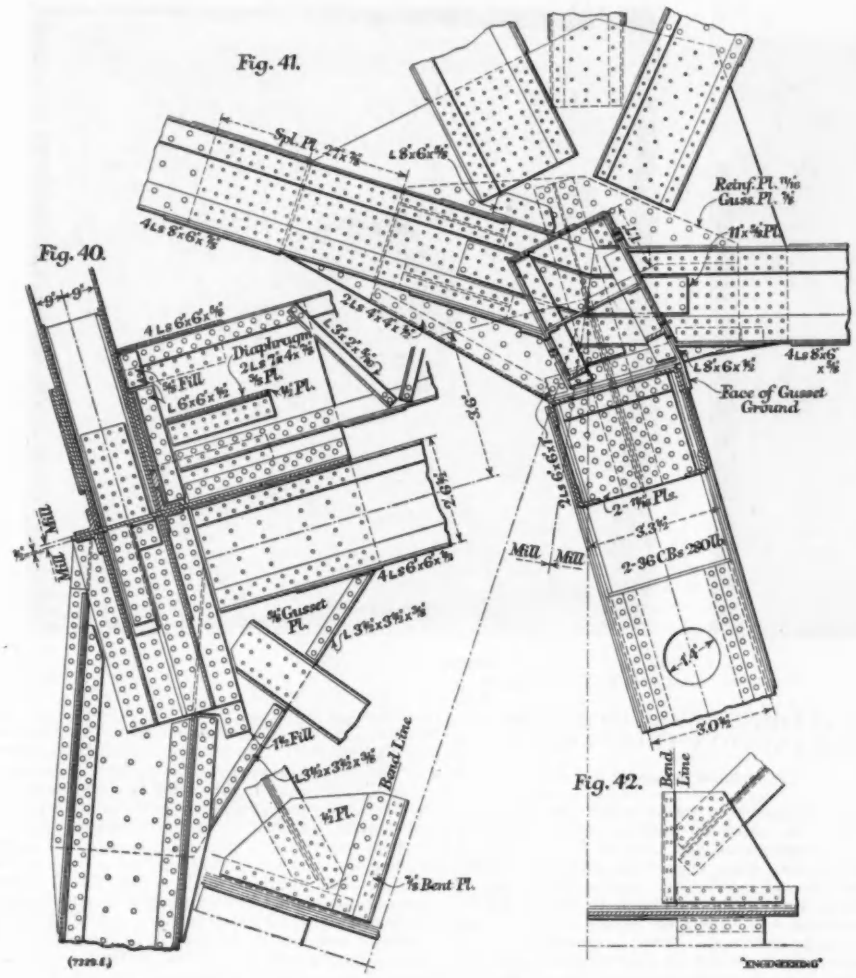
(Continued from page 4.)

IN view of the facts that the bridge is situated close to the Gulf of Mexico, in a region frequently visited by tropical hurricanes, and that it is of unusual height, it was necessary to give great attention to questions of wind pressure. The design of the structure follows closely the 1935 specification of the American Association of State Highway Officials, except that the floor sections, anchors and similar members are designed for a moving load consisting of a 20-ton lorry preceded, or followed, by a 15-ton lorry. In order to resist wind forces during hurricanes, a pressure of 75 lb. per square foot was assumed for the unloaded structure, this figure being taken for both longitudinal and cross loading, and for winds at an angle of 45 deg. in both directions. It was assumed that the wind pressure on any moving vehicles on the bridge would not exceed that equivalent to 30 lb. per linear foot of the structure. A wind force of 75 lb. per square foot was considered to be equivalent to a wind velocity of approximately 140 m.p.h. In this connection, and as mentioned in our last article, it is of interest that consideration of wind forces had greater effect on the design of the substructure than on that of the superstructure.

In addition to the question of wind velocity, consideration had to be given to the fact that the atmosphere is salt-laden and polluted with oil-refinery fumes. In view of this, provision was made in the specification for the use of copper-bearing steels, and some experimental work was carried out to assess the relative value of this material as compared with plain carbon steel. There is considerable difference of opinion about the practical value of introducing copper into structural steels, but the results of tests carried out by the American Society for Testing Materials appeared to indicate that such addition has some merit in preventing corrosion in steels subjected to atmospheric exposure. In view of the conditions ruling, the specification also called for additional concrete cover on the reinforcing steel of the floor slabs.

A general view of the whole of the 7,752-ft. bridge is given in Fig. 18, on Plate VI, a longitudinal elevation of the southern half of the structure being given in Fig. 19, and various cross sections in Figs. 31 to 39, on this page. The extreme south end of the approach is formed by twelve reinforced-concrete spans varying in length between 30 ft. 9 in. and 32 ft. 9 in., and making up a total length of 381 ft. 1½ in. A characteristic cross-section, showing one of the concrete piers, is given in Fig. 39. These are followed by fifteen girder spans, carried on lattice frames and triangular towers, and each 60 ft. long. These make a total length of 900 ft. 10½ in. A cross-section of this part of the approach is given in Fig. 35, and an end view of one of the lattice frames in Fig. 38. The next ten spans are of the lattice-girder type, the various lengths being given in Fig. 19. The inner two of these spans—those between piers 35 and 37—form a continuous span. A cross-section through the span between piers 28 and 29 is given in Fig. 34, and an end view of pier 29 in Fig. 36. A similar

THE PORT ARTHUR-ORANGE BRIDGE, TEXAS.



section and an end view for a position nearer to the centre of the bridge are given in Figs. 37 and 33. As shown in Fig. 19, and as explained in the earlier section of this article, the whole of the piers for these spans, up to pier 34, are carried on pile foundations.

As already mentioned, the bridge is designed to meet the condition that the free passage below it shall be 600 ft. wide and 176 ft. high. As will be seen from Fig. 19, the actual headroom provided for the centre 400 ft. of the bridge is 176 ft. 9 in. The horizontal clearance of 600 ft. is between the fender piles which protect the inner piers. There are dolphins at the outer ends of these piles, furnished with navigation lights. The maximum height of the roadway above mean water level in the Gulf of Mexico is 184 ft. and the highest point of the structure is 230 ft. above this level. The length of the main span is 680 ft., this being made up of the two inner arms of the cantilevers, each 170 ft. long, and a centre 340-ft. suspended span, a cross section through which is shown in Fig. 32, on page 64. The outer arms of the cantilevers, which form the spans on each side of the main span, are each 374 ft. long. The cantilevers are carried on triangular steel towers which are built into and form integral parts of the spans. An end view of one of these towers, that at pier 38, is given in Fig. 31, opposite. The piers on which these main towers stand, and which form part of the 32-ft. diameter caisson foundations described in our previous article, are spaced at 110-ft. centres. As will be seen from Fig. 19, the centre supports of the 600-ft. continuous-deck truss spans, which form the next two sections of the bridge on each side, also take the form of triangular towers of the same general form as the main towers. One of them is shown in Fig. 33, which has been already referred to. The caissons on which these towers stand are 22 ft. in diameter and are placed at 84-ft. centres. The supports at the outer ends of the continuous spans and at the points where they join the cantilever arms are in the form of plain lattice frames carried on 18-ft. diameter caisson foundations. In the former case the caissons are at 80-ft. centres; in the latter, at 105-ft. centres.

Various details showing the construction of the two main triangular towers are given in Figs. 20 to 23, on Plate VI. Although the trusses of the main span are only 34 ft. wide, the tower bases, as already mentioned, and as shown in Fig. 31, are set at 110-ft. centres. The purpose of this very considerable splay is to resist the overturning moment of hurricane winds. The bases of the towers are pin-jointed to the tops of the piers carried by the caisson foundations. The arrangement is shown in Figs. 20 to 22. A cast-steel shoe, 5 ft. 8 in. wide by 7 ft. long, is secured to the pier by four 3½-in. diameter anchor bolts. It rests in a recess left in the top of the pier and, when it had been secured in position, the recess was filled in with concrete embedding the lower part of the shoe, as indicated in Figs. 20 and 22. A sheet of lead, ½-in. thick, was placed below the shoe to ensure even bedding. A second cast-steel member of complicated form, of which two views are given in Figs. 22 and 23, is secured to the steelwork of the tower. This works on the 8-in. diameter pin, forming the connection between the pier and the tower. The main posts which connect the hinge to the bridge truss are approximately square in cross-section, and are built up of two 8 in. by 6 in. by ¾ in. and two 6 in. by 6 in. by ⅝ in. angles, with four 32 in. by ¾ in. and two 36 in. by ⅞ in. plates. The outer cover plates of these posts are riveted to the outer faces of the cast-steel joint piece, which are machined. The inner cover plates, that is, those that meet in the Vee formed where the two posts come together, are secured to the joint piece by straps made from ½-in. plate. These are shown in Fig. 22. This arrangement is necessary since, as shown in Fig. 23, the joint piece is stiffened by internal webs, so that a wide surface is not available for the joint with the posts. The faces between the webs, with which the straps make connection, are also machined. The lower ends of the posts, where they come together, are connected by fitting outer cover plates, as shown in Fig. 20. These are connected together by ⅞-in. diaphragm plate stiffened with two ⅝-in. plates. After completion of the riveting, the interior spaces of the lower parts of the posts and the joint piece were filled with concrete.

The complicated arrangement at the pin joint is further elaborated by the connection to the horizontal strut, which, as shown in Fig. 31, joins the base of one pair of posts to those of the other on the second pier. This strut is wider at the top than the bottom, owing to the fact that it has to make connection with the base of the posts when they meet at an acute angle. The strut is built up of eight 6 in. by 4 in. by ⅝ in. angles, with three vertical plates of which the centre one is ⅞-in. thick and the outer ones ⅝ in. It is of lattice construction, the horizontal members being straps made from ½-in. plate. The strut is connected to the posts by double ⅝-in. cover plates on each side, as shown in Fig. 20 and 21, and is also connected to a 2½-in. machined lug on the cast-steel joint piece. This is shown in Fig. 23. As shown in Fig. 31, inclined bents connect the centre of this strut to the post joints of the strut above. These bents are built up of angles and plates.

Drawings showing the connection between one of the tower posts and the bridge truss are reproduced in Figs. 40 to 42, on page 66. The panel point detailed is that marked x in Fig. 19. As will be clear from this figure, in conjunction with Fig. 31, the post connects to all the truss members at either an acute or obtuse angle, there being no straightforward right-angle connection at the joint. As shown in the lower part of Fig. 40, the top of the main post is stiffened with external 8 in. by 4 in. angles on the 3 ft. 0½ in. faces and by ⅜-in. diaphragm plates, which are set at an angle to suit the main cross-girders of the bridge. These girders connect to the post by cover plates and angles. Connection, in the other plane, to the lower bridge booms, shown in Fig. 41, is made by stiffened cover plates secured by angles to a heavy diaphragm on the top of the post. The booms are built up of 8 in. by 6 in. angles, with cover plates, in the same manner as the main posts. The lighter diagonals and the vertical member connecting to the top boom are secured by ⅞-in. gusset plates, as shown in Fig. 41. These gusset plates have 11/16-in. reinforcing plates at their lower ends. The vertical members connecting to the top boom are built up of 6 in. by 6 in. and 6 in. by 4 in. angles, with ¾-in. cover plates. Fig. 42 shows the connection to the sway bracing.

It will be seen, from Fig. 19, that triangular towers are also used for one of the outer 191-ft. span groups, and also for two of the joist spans. Details of one of these, referring to piers 32 and 33, are given in Figs. 24 to 27, on Plate VI. These piers, as shown in Fig. 19, and as described in the previous part of this article, are carried on pedestals supported by inclined piles. As in the case of the main piers, the towers stand on cast-steel shoes, as shown in Figs. 24 to 26. In this case, however, the shoes are not embedded in the concrete of the piers, but are provided with lugs on the lower side, which are set in the concrete. The shoes are held down by four 2½-in. bolts. The steelwork of the posts is connected to a cast-steel bottom member, which is bolted to the shoe by 1½-in. bolts, and in addition is prevented from moving by its engagement with a lug on the top of the shoe. Slotted holes in the lower casting permit of slight adjustment. The arrangement of the lug is shown in Figs. 26 and 28. The lower ends of the posts are riveted to faces provided on the upper casting and are provided with cover plates, as shown in Figs. 24 to 26. The horizontal strut is connected by means of two ⅝-in. gussets reinforced by 3½ in. by 3½ in. angles at their outer edges, as shown in Figs. 25 and 26. A plan view, showing the

IMPACT TESTS ON GLASS TILES.

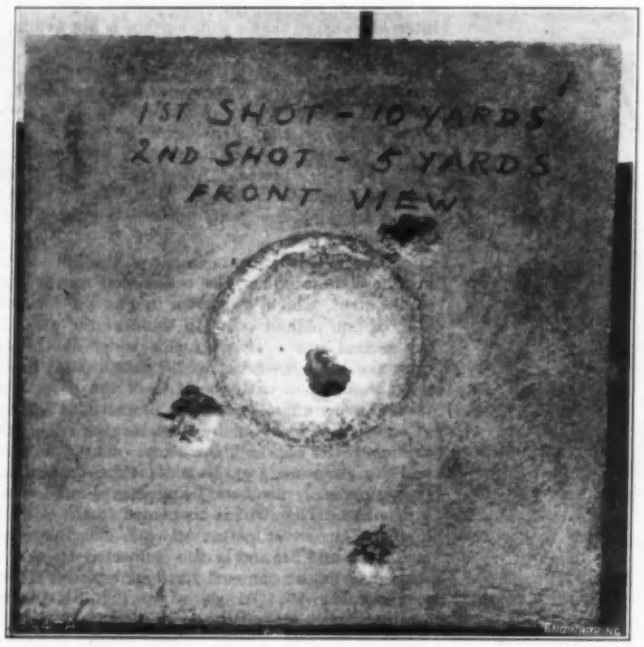


FIG. 1.

FIG. 2

connection of the strut to the lower casting, is given in Fig. 27. The connections to the horizontal struts higher up the posts, and the connections between these posts and the diagonals, are shown in Figs. 24 and 25. Two drawings showing the base of the towers used at piers 28 and 29 are reproduced in Figs. 29 and 30, Plate VI. As is shown in Fig. 19, these piers are situated near to the outer end of the truss-span section of the bridge. Apart from the fact that they are of lighter construction, they are generally similar to the towers at piers 32 and 33, and require no detailed comment.

(To be continued.)

IMPACT TESTS ON GLASS TILES.

SOME impact tests were recently carried out by the research department of Messrs. Pilkington Brothers, Limited, St. Helens, by firing a revolver at tiles made of toughened Armourlight glass. As will be seen from the accompanying illustrations, the tiles were mounted in concrete slabs, 5 in. thick, and were arranged either singly or in pairs, one behind the other. In general, the single tiles were broken when a 0·45-in. bullet was fired at them from a Colt revolver at a range of 10 yards, while in the case of the double units, though the front tile was pierced and diced, the rear tile was undamaged even when the range was reduced to 5 yards. The general conclusion is that, while a single glazed tile will offer some protection, double glazed tiles are very resistant, even after the front tile has been shattered.

Fig. 1 illustrates the front of a concrete slab, 5 in. thick, in which a double glass tile, 7 in. in diameter, had been embedded. The first shot, which was fired at a range of 10 yards, pierced the front tile with a hole 1 in. in diameter and knocked a cone out of the back, as shown in Fig. 2. The front tile was diced and the bullet was found between the two tiles. The rear tile was not damaged, except for a slight mark where the bullet had touched. The second shot, which was fired at a range of 5 yards, grazed the edge of the previous hole, but did not damage the rear tile in spite of the fact that the bullet struck the front tile where it was very thin owing to the powdering caused by the first shot. A mark of splashed lead was visible on the rear tile.

CANADIAN NATIONAL EXHIBITION.—A Canadian National Exhibition is to be held at Toronto, from August 23 to September 7. Particulars regarding the function may be obtained from the London office of the Exhibition, British Columbia House, 3, Lower Regent-street, London, S.W.1.

EARTHING PRACTICE AND PROTECTION FROM SHOCK.

(Concluded from page 46.)

RODS or pipes driven vertically into the earth were also universally used for earthing both consumers' circuits and equipment, and, in many localities, distribution systems. They offered the advantages of low cost and ease of installation. Under favourable soil conditions, they might be driven to the permanent moisture level—an important feature in maintaining low electrode resistance. From the point of view of resistance, the material of the electrode was not important, since there was very little drop in the electrode itself. In Ontario, mild steel rods, ¾ in. diameter, 10 ft. long, and ungalvanised, had proved quite satisfactory. The corrosive effect of the soil and of chemicals used to test the ground was negligible. The theoretical characteristics of the rod might be calculated from Dwight's formulæ and curves,* which had the great practical advantage that attainable earth resistances might be estimated from measurements on a few temporary test earths. The practice of testing the resistance of transformer and consumers' earth electrodes at the time of installation was quite general in Canada. In Ontario measures were taken to obtain, if practicable, resistances of 25 ohms or less in all transformer earths, either by driving additional rods or by treating the ground with common salt. As a typical example of the results obtained, 23,164 earths were tested in 1934, of which 17,359 were reduced to 25 ohms or less by these methods. In some localities it was impossible to obtain the desired resistance, except at great cost; for example, where rock underlaid sand or on gravel hill tops high above permanent moisture level. This condition might not be serious if the neutral was earthed at many points in parallel and had a low overall and uniform resistance to earth throughout the system. However, if the earth should be located at the end of a line, so that it would be isolated if the neutral wire broke, a special effort was made to reduce the resistance to the minimum value. In Ontario, resistances above 25 ohms were reported to the supply authority, which was expected to reduce the transformer earth resistance to a lower value. A study of these resistance measurements, made over a period of years, showed that in clay the most probable value was about 10 ohms, in sandy loam about 30 ohms, and in gravel about 50 ohms.

Investigations to compare the characteristics of various type of electrode were recently undertaken in Ontario. Eight test stations were installed in four different classes of soil and measurements extended over a two-year period. The types of electrode included wire mesh and copper strips at various depths, ½-in. steel rods from 6 ft. to 20 ft. long, some of which were treated with salt, perforated pipes containing salt solution and T- and star-shaped rods. The stations were located in clay, sand, gravel and in soil underlaid with rock at several depths. Seasonal variations of as much as 2,700 per cent. were found for some electrodes. Maximum values of resistance occurred in mid-winter or mid-summer; minimum, in the spring or autumn. Precipitation was the most important single factor affecting the resistances. In localities where a shallow layer of earth overlaid rock, a strip electrode was better than a mesh. Frost destroyed the effectiveness of an electrode. Soil treatment was valuable in reducing resistance and was most effective in dense soils. It might often be more economical to treat single electrodes than to install additional rods. A 10-ft. by ¾-in. steel rod would appear to have the best seasonal characteristics for use as an artificial earth. It was usually possible greatly to lower the resistance values by driving rods in parallel. Where it was possible to drive larger rods, this practice would be found more effective in many cases than driving additional rods in parallel. The effectiveness of an earthing system was determined by its impedance at the frequency of the disturbance. Consequently it was important to ascertain the effects of high frequencies and steep wave front discharges. Investigations showed that the impedance decreased with increasing frequency, and that in cases where multiple earths were used the impedance of the inter-connecting wires was frequently of great importance and the characteristics of the earth electrode relatively unimportant.

It might possibly be inferred from this survey of earthing practice that the situation with respect to personal safety was not satisfactory; and that the many exceptions to earthing rules indicated the ineffectiveness of earthing as a means of protection. In this respect, judgment must be based upon the results as given in accident statistics and upon the potential hazards which might be deemed to exist and which were not provided for at present. Earthing was so intimately connected with the operation of electrical systems that there was no possibility of its being abandoned. The technical arguments in its favour were too weighty. The practice of earthing non-current-carrying metal parts might, however, be subject to modification, and it could not be concluded that present methods would be continued indefinitely. Based upon accident statistics, it would appear, however, that the results were in general satisfactory. In Canada, the industrial shock fatalities had been at the rate of about two per million of population. In England, the average for five years was 2·1. The ten-years' average for Switzerland was 6·2, and in several other countries it varied from 4 to 6·7. In the United States, from 1913 to 1935, the ratio was seven per million. This was the lowest of six causes of accidents, motor cars being responsible for 40 per million. From these figures it would appear that the measures taken to protect the public from injury in the use of electricity had resulted

* See *Electrical Engineering*, vol. 55, page 1319 (1936).

in a very satisfactory accident record, as compared with other agencies.

It had been stated by advocates of alternative methods of protection that present methods had failed miserably. This sweeping statement was not borne out by evidence in Canada. It was apparent, however, that no general solution for the problem of earthing existed at present and that alternatives were necessary in certain cases. The greatest defect in the system was the difficulty of obtaining and maintaining low electrode resistance, especially in rural areas. The second important difficulty rested in the construction of appliances and their manner of use by the public. Portable appliances, particularly, deteriorated more rapidly than any other item connected to electric systems. They were less carefully maintained in the hands of the public than equipment in industrial locations and on distribution systems. Carelessness in their use and home repairs were responsible for accidents. Further, certain portions of houses, particularly bathrooms, must be regarded as hazardous locations. The temptation was great to use appliances there, particularly heaters and electric razors. As already stated, the Canadian Electrical Code, as far as possible, prohibited the use of portable appliances in these locations. This was as far as administrative control could go. Further steps must involve educational efforts to inform the public in the proper use of appliances and it might be said with some confidence that efforts in this direction had produced some results. Another objection which had been advanced against the practice of earthing was the possibility that breaks in conductors, particularly neutral conductors on consumers' premises, might destroy protection. While this was true, it was also a fact that few cases of breaks in neutral wires had occurred and only two fatalities of this kind had been reported in Ontario and none on domestic installations. The regulations, in general, prohibited the earthing of non-current-carrying metal parts to the neutral in the consumers' circuit except at the service entrance. The reason for this was the fear of breaks in neutral conductors, but in the light of experience there were reasons for permitting this practice on domestic installations.

The chief difficulties in earthing practice were met with in the rural sphere, where high earth resistance was most frequently encountered. This introduced a potential hazard which was not present elsewhere. The alternatives provided for in the regulations were not always applicable and other methods would have to be devised. At least two such methods had been proposed, and one of them had been advanced to the stage of commercial application. This was called "earth leakage protection" and consisted essentially of a circuit breaker connected to the exposed non-current-carrying metal parts of the equipment in such a manner that the power supply would be interrupted, should a dangerous voltage appear on the exposed parts. The method had been developed in Germany and was in use to some extent on the Continent and in Great Britain and Australia. Theoretically, it would appear to offer complete protection irrespective of the value of the earth resistance—an advantage not offered by other methods. The continuity of the earthing conductor was, however, essential to its successful operation, and its non-selectiveness was a disadvantage. The other method referred to also disconnected the supply, if voltage should appear on a metal part. It did not require additional conductors like the earth-leakage circuit breaker, but it did necessitate the consumers' circuits being isolated from other consumers. This would limit its application, since a separate transformer would be required for each consumer.

While there was no reason for assuming an alarmist attitude concerning the defects in earthing practice, the situation, particularly as it applied to rural localities, should not be viewed with complacency. The potential hazards should not be overlooked, since they might assume increasing importance as the use of electricity became more widespread. Economy should not be the governing factor in deciding upon protective measures. In fact, it was difficult to ascertain whether unsatisfactory protection at low cost was the most economical solution. Accidents involving workmen were often expensive. While it might be impossible to reach finality in earthing practice, progress might be made by co-operative effort along several lines. Further progress on an accelerating scale could be made in securing low earth resistance and efforts should be increased in this direction. The statement had been made that more was known about electrical phenomena in the atmosphere than in the ground, and that earth characteristics varied far more widely than atmospheric characteristics. This pointed to the necessity for more research on earth characteristics, an effort which would be justified in view of the large amount now spent on earth protection. Much could be done in this field to bridge the gap between theory and practice and to investigate the economic as well as the technical aspects of the design of earth electrodes. The correlation of earth-resistance measurements made in different districts would be an important initial step and should lead to a better understanding of the economics of earthing practice and of the possibilities of securing earths of low resistance. Alternative methods of protection should be investigated and developed. Standards for materials and regulations respecting installations should be maintained at a high level as necessary supplements to earthing technique.

THE GRAND UNION CANAL.—It is understood that the portion of the Grand Union Canal known as the Cumberland arm and basin, in the borough of St. Pancras, is to be abandoned, and eventually will be filled in.

ROTARY FILING MACHINE.

MESSRS. LORANT AND COMPANY, LIMITED, LONDON.

FIG. 1.

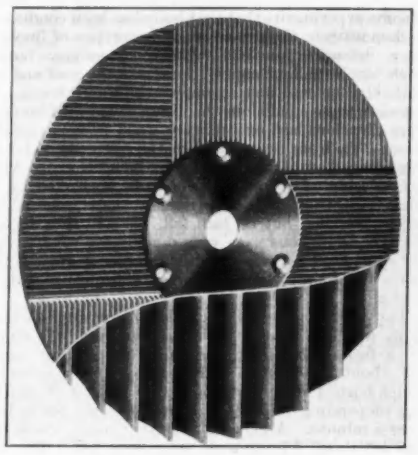


FIG. 2.

ROTARY FILING MACHINE.

THE reciprocating filing machine, and that in which the files are arranged in an endless belt and used in a band-saw type of machine, have individual advantages, but it would appear that the rotary filing machine shown in Figs. 1 and 2, on this page, is able to function in a field hitherto unoccupied. The machine, which is known as the "Rindis" universal filing machine, has been recently introduced by Messrs. Lorant and Company, Limited, 98-100, Croydon-road, London, S.E.20, who claim that it is capable of roughing out and finishing in one operation not only ferrous and non-ferrous metals, but plastic materials and wood, the single operation, in conjunction with the high speed of rotation, resulting in a considerable saving of time compared with hand filing. Moreover, apart from its use in relieving other machine tools, such as lathes, milling machines and grinding machines, it can be operated by unskilled labour. In some cases, it is stated, it can replace certain machines altogether; thus, aluminium and its alloys, magnesium, copper, plastics, wood and soft materials generally do not respond well to grinding but are satisfactorily handled by filing, an operation which markedly reduces fire risk when magnesium alloys are being worked.

The machine consists essentially of a double-sided filing disc about 10 in. in diameter, driven by Vee-belt and through speed-change gears by a ½-h.p. protected-type motor, and is arranged as shown in Fig. 1. The disposition of the teeth on the disc is unusual. As seen in the detail view of Fig. 2, they are not radial but are disposed in four quadrants, the teeth in each quadrant being at right angles, as regards their length, to those of the quadrants on each side of it. It will, of course, be realised that the lower portion of this illustration is merely a view of a few of the teeth greatly enlarged so as to show their individual form. The discs, which can be supplied with either "rough" or "smooth" teeth, are made from an alloy-steel and are hardened. The teeth are undercut, but the swarf, from the arrangement and contour adopted, does not clog them, but clears itself automatically. The arrangement further ensures effective cutting owing to the angle at which the teeth are passed across the work. It is stated that both sides of the disc will retain sharp cutting edges for periods ranging from three months to six months and that, when the discs are blunt, they can be readily re-sharpened. The motor runs at 1,435 r.p.m., and has a continuous rating of ½ h.p. The disc, of course, runs more slowly, and 9 speed changes are provided, a range which covers the majority of materials. The recommended disc speeds are: for cast iron, 85 r.p.m.; for wrought iron, 100 r.p.m.; for steel, 110 r.p.m.; for bronze, 200 r.p.m.; for brass, 235 r.p.m.; for Babbitt metal, 255 r.p.m.; for Bakelite, 285 r.p.m.; for aluminium and magnesium, 315 r.p.m.; and for wood, 360 r.p.m.

As regards constructional details, the base is of cast iron and the disc spindle and shafts are of high-tensile steel, mounted in adjustable ball bearings to take both axial and radial thrust. The motor is housed inside the base and drives the speed-change gear by means of a Brammer Vee-belt. The motor bracket enables belt tensioning to be readily effected. The gears are designed to run silently, and are protected by a removable cover. Control is by means of a push-button starting switch with overload protection, the switch being mounted on the left-hand side of the base. The work is supported on a tilting table with a surface measuring 14½ in. by 6 in., and provided with slots for the attachment of jigs or fixtures for repetition work. A tray is inserted between the swivelling base of the table and its supporting bracket. The height of the machine, from the floor to the centre of the disc, is about 39 in. and the floor space occupied is 26 in. by 22 in. The total weight, including the motor, is approximately 3 cwt.

ELECTRIFICATION OF THE NEW PRALHAD MILL, BOMBAY.

BOMBAY, which is the centre of the important Indian textile industry, contains some 63 mills of different outputs. Among these is the New Pralhad Mill, which is equipped with 31,500 spindles and 963 looms, and may be regarded, therefore, as being of medium size. It comprises preparatory, spinning and weaving departments, as well as a large dyeing, bleaching and finishing section, and its range of products includes longcloth, dhoties, saris and cotton blankets. Until about ten years ago, the power for operating the machinery installed was provided by a Hick Hargreaves two-cylinder horizontal cross-compound engine fitted with Corliss valves. This was built in 1902, the original cylinders being 30 in. and 56 in. in diameter and having a 5-ft. stroke. It was capable of developing an economic load of 1,430 indicated horse-power when running at 63 r.p.m., and supplied with steam at a pressure of 125 lb. per square inch. At a later date,

a new low-pressure cylinder with a bore of 58 in. was fitted, thus increasing the output to about 1,700 h.p.

By the end of 1938, however, the equipment of the mill had increased to such an extent that the engine was working to its full capacity, and, as various extensions were planned, the question of providing additional power had to be considered. In dealing with this problem, however, it had to be remembered that a considerable amount of process steam was required. The original proposal was, therefore, to provide electric drive for the looms and dyeing, bleaching and folding departments, a total load of about 1,000 h.p., and to leave the carding, roving and spinning departments to be driven by the steam engine, but further consideration showed that it would not be economical to convert only a part of the mill, and a scheme for complete electrification, which has now been carried out by Messrs. Crompton Parkinson, Bush House, London, W.C.2, was, therefore, drawn up. The boilers have been retained to produce process steam, although the fuel has been changed from coal to oil. The engine has, of course, been dismantled.

The electrical energy required for operating the plant is obtained from the Tata Electric Power Company at 22 kV, and is controlled at the point of entry to the works substation by circuit breakers and air-break isolating switches through which it passes to an overhead 'bus-bar system. To this system the high-tension sides of three 1,000-kVA transformers, constructed by Messrs. The British Electric Transformer Company, Limited, Hayes, Middlesex, are coupled, while their low-tension sides are connected through two single-core 1-sq. in. paper-insulated lead-covered cables per phase to the distribution switchboard. This board consists of 17 ironclad cubicles, three of which control the transformers, and one the lighting system, while three others control condensers of 850 kVA for power-factor correction and ten control that number of outgoing feeders. Although the scheme includes six 175-h.p. motors, which could conveniently have been supplied at 2,200 volts, a distribution pressure of 400 volts was selected throughout, since it was felt that any future extensions could be most easily dealt with at this voltage. In addition, it is claimed, a single voltage system gives greater flexibility and sufficient transformer capacity to be provided without installing more than three transformers. The capital cost of standby capacity is, of course, important where, as in this case, the site limits the ultimate extensions.

It was naturally important that the mill should not be shut down during the change over, and it was, therefore, a condition of the contract that this should be carried out without interfering with production. In some of the departments the methods adopted were influenced by this consideration. In the majority of the departments, the original line-shaft drive was retained, though the total horse-power on each shaft has been reduced by sub-division. The calendering and mixing departments have been re-arranged for individual electric drive to the machines, and the air compressors are similarly driven. The line shafts are driven by screen-protected or pipe-ventilated motors, depending on their situations, and for motors up to 40 h.p. Crompton Tork pattern machines are employed. There are 29 cross-shafts in the loom sheds, and these are each driven by one motor with an output of either 20 h.p. or 16 h.p. The four calenders are driven by variable-speed slip-ring motors through Fenner Vee-rope drives and are controlled by drum controllers. The three compressors are driven in a similar way, though in this case constant-speed slip-ring motors are employed. The main group drives in the carding, raising and ring-spinning departments, and in the blow rooms, are operated by slip-ring motors working through Renold and Coventry bush roller chains, of which a total of 51 are in use. Altogether 70 motors, with an aggregate output of 2,600 h.p., have been installed.

As will be gathered, the distribution system is fairly extensive, and actually nearly two miles of cable had to be laid to connect the substation to the distribution boards in the various departments. As cable-laying had to be carried out in July and August, which are usually the wettest months of the monsoon, it is fortunate that last year the rainfall was much below the average, and little trouble due to flooding of the trenches was experienced. Alterations to the substation building proceeded at the same time as the cable-laying. The transformers, substation switchgear and cables were put into commission by the third week in September, the first motor being run immediately after. At that time, the mill was working single-shift and the majority of the motors were, therefore, installed at night, so as not to interfere with production. At no time were more than a few machines stopped, and as the change over proceeded, most of the departments were put on to double shifts. The result of the change over has been that since the outbreak of war, increased production has been obtained in a way which would not have been possible with the steam-engine drive.

THE FIRE-RESISTING QUALITIES OF LINOLEUM.

AN informative pamphlet, which has recently been issued by The Linoleum and Floorcloth Manufacturers' Association, Staines, Middlesex, deals with the results of some experiments that that body has been conducting to demonstrate the fire-resisting properties of linoleum as a defensive measure against incendiary bombs. Such bombs will, of course, penetrate the roof and will probably come to rest on one of the upper floors. To simulate these conditions the different types of linoleum were therefore laid on ordinary wood flooring, erected about 2 ft. from the ground in the open air and 1 kg. incendiary bombs were used, this being the size which it is considered are most likely to be employed by the enemy. During the experiments there was a stiff breeze blowing, but no rain fell. It will thus be seen that the conditions were very much more conducive to the spread of fire than would be the case in the confined space of a room, where air currents would probably be negligible.

The bomb, which was of the magnesium-Elektron type, was laid on the floor covering and was ignited by a fuse. Thereupon the thermite priming burned for about 5 seconds, followed by the magnesium, which burned fiercely with a certain amount of spluttering (depending on the moisture present) for a little over a minute. A glowing white-hot mass, which died out in about 35 minutes, was then left. The first series of photographs reproduced in the pamphlet show the results after the bombs had burnt for about 10 minutes and indicate the effects on plain wood flooring which had been both treated and untreated with fireproof paint and when the same treated and untreated flooring had been covered with linoleum 6·70 mm. in thickness. Though it is clear that fireproof paint offers some measure of protection, after 10 minutes the bomb had burned right through the wood and would have fallen to the floor beneath. In the case of the untreated wood, the damage was, of course, much more extensive. When the untreated wood was covered with linoleum, however, though the surface of the latter was charred, the wood flooring was not burnt through. The damage was even less extensive in the case of the treated wood.

In a further series of tests, the bomb was allowed to burn right out, an operation which, as already stated, occupied 35 minutes. In one case it was laid on plain brown linoleum, 6·7 mm. thick, which, 4½ minutes after the commencement of ignition, could be lifted up and showed no penetration by the burning mass. After another 2 minutes the linoleum showed slight signs of penetration, while 11 minutes from the start the wood of the flooring was found to be ignited. After 35 minutes the original area covered by the burning bomb had not extended, though the wood underneath was charred on the surface, with a tendency to burn more deeply at the joints, especially where there was a chance of air coming through. The linoleum was only damaged immediately beneath the burning mass. In the case of first-grade sheet marble linoleum, 3·3 mm. thick, the results were very similar, except that the wood was found to be crackling after 8 minutes, while with X-quality plain linoleum, 1·9 mm. thick, the linoleum was burnt to a greater extent than before and the wood was more extensively charred. It is, therefore, evident, as might be expected, that the thicker the linoleum used the greater will be the degree of protection afforded. Plain cork carpet, 6·5 mm. in thickness, gave results very similar to those obtained with brown linoleum, 6·7 mm. thick, though the confinement of the burning to the original area was most marked, a clean hole being burnt through the material.

ENGINEERING TRAINING AND EDUCATION.

Engineering Apprenticeships at Austin Motor Company.—In September, five new engineering apprentices will be accepted by Messrs. Austin Motor Company, Limited, Longbridge, Birmingham, for a training period of four years, or until the age of 21 is reached. The age of entry is from 16¼ to 17¼ years. For the first two years apprentices receive a general training in the fundamentals of engineering practice. At the end of this period some specialisation may suggest itself and the apprentices department of the firm is usually consulted in the matter. Courses at the Birmingham Central Technical College are arranged in collaboration with the educational authorities. Great attention is paid to punctuality and diligence in both work and study, for which various bonus and prize awards are made, in addition to a regular rising scale of wages. We understand that early application should be made for the five vacancies and candidates should at least have passed the school certificate examination of a recognised University.

PERSONAL.

THE Council of the Institution of Mechanical Engineers have appointed MR. C. W. J. TAFFS, M.Sc. (Lond.), to be assistant secretary of the institution, an office which has been vacant since Mr. J. E. Montgomrey was appointed secretary in March, 1939. Mr. Taffs, who joined the staff of the Institution in 1921, acted as secretary of the Marine Oil Engine Trials Committee from its inception in 1923, and has been concerned in a similar capacity with other research committees and with the Internal-Combustion Engine Group of the Institution.

MR. J. C. CROCKER has been appointed to succeed MR. C. DORÉE as head of the Department of Chemistry at the Chelsea Polytechnic, London. Mr. Dorée is retiring on August 31.

DR. MAURICE COOK, M.Sc.(Manch.), Ph.D.(Cantab.), research manager, Messrs. I.C.I. Metals, Limited, Witton, Birmingham, has been awarded the degree of D.Sc. of Manchester University.

MR. ROBERT FISHER, who has been secretary of Messrs. Archibald Russell, Limited, 115, Wellington-street, Glasgow, C.2, for the past 23 years, retired at the end of last month.

In connection with our announcement, on page 622 of our issue of June 28, that MR. ARNOLD WALTERS had been appointed representative of Messrs. Newton, Chambers and Company, Limited, for blast-furnace and steelworks plant in Scotland, we are informed that he is not leaving Sheffield, but is continuing to conduct the business of Messrs. Arnold Walters and Company, Station-road, Hathersage, near Sheffield. Mr. Walters is also technical agent for Messrs. Gaston E. Marbaix, Limited (Farval Division), for Messrs. Alfa-Laval Company, Limited, and is English and Welsh technical agent for Messrs. International Construction Company, Limited.

TENDERS.

WE have received from the Department of Overseas Trade, Great George-street, London, S.W.1, particulars of the undermentioned tenders, the closing dates of which are as stated. Details may be obtained on application to the Department at the above address, quoting the reference numbers given.

Electric Lifts, seven for passengers, two for goods, and three service lifts, at new G.P.O. Building, Cape Town. Union Tender and Supplies Board, Pretoria; September 19. (T. 21,012/40.)

Low-Tension Switches. With regard to the call for tenders for one bank of six air-insulated low-tension switches, noted on page 28, *ante*, we now learn that the Union Tender and Supplies Board, Pretoria, has extended the closing date from August 8 to August 29. (T. 20,775/40.)

Accumulator, 20-cell, 250 ampere-hour, to B.S.I. Specification No. 440-1932. Union Tender and Supplies Board, Pretoria; August 22. (T. 21,009/40.)

Air Diffusers, six hundred, 6-in. by 36-in. nominal size, with 600 needle valves, bends and unions. Also 54 air diffusers, 6-in. by 54-in. nominal size, and 50 needle valves, bends and unions. City Council, Johannesburg; August 17. (T. 21,010/40.)

Air-Conditioning Plant for the new Magistrates' Courts, Pretoria. Union Tender and Supplies Board, Pretoria; August 22. (T. 21,013/40.)

Electric-Light Fittings for 200-volt, 50-cycle, single-phase alternating current at G.P.O., Bloemfontein, comprising 25 rod pendant bowl fittings, each to house one 125-watt high-pressure mercury-vapour lamp and three 150-watt tungsten-filament lamps, and complete with mercury-lamp choke and condenser. Also 60 fittings similar to the above, but with mercury lamps, chokes and condensers suitable for 80 watts. Union Tender and Supplies Board, Pretoria; August 22. (T. 21,015/40.)

PHYSICAL PROBLEMS IN INDUSTRY.—In order to assist professional men who, in the present emergency, find themselves presented with technical problems in applied physics of which they have had no previous experience, it has been decided to extend the facilities of the Institute of Physics' panel of consultants. Through this medium, inquirers are put into touch with those physicists most likely to be able to offer immediate practical suggestions in any particular case. The subjects which can be dealt with cover all branches of physics, both pure and applied, including, for example, physical measurements and testing, the design and supply of scientific instruments for special purposes, and the control of processes by physical means. Inquiries concerning the scheme should be addressed to the secretary, The Institute of Physics, at the University, Reading, Berks.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Welsh Coal Trade.—A plea for the pooling of markets by all the coalfields of the country and for the maintenance of production at the highest level was made by Mr. Ness Edwards, M.P. for the Caerphilly division, one of the South Wales representatives at the annual conference of the Mineworkers' Federation of Great Britain last week. He urged that coal should be exported even if there were no immediate sale for it, and that large stocks should be built up in the Colonies ready for any market that could be found. The trade chiefly affected by the scheme for sharing business was that with inland consumers. During the years of depression, South Wales made many attempts to secure a more equitable share of this business, but without much success. Of late, however, there has been a definite increase in the number of inland inquiries received on the local market, and the business concluded has enabled collieries generally to offset, to a large extent, the effects of the cessation of the French and Italian trades. In addition to increased demand due to the greater activity in the country's industries, there has been a large volume of business available from home users, who were paying heed to the appeal made by Mr. D. R. Grenfell, the Minister of Mines, that they should lay in heavy stocks of coal as a precaution against any repetition of the shortage that was encountered during the severe weather in the early part of the year. Export demand remained rather quiet, interest being chiefly centred on the South American and Portuguese trades; deliveries to Eire were satisfactorily maintained. Coals were not so freely available owing to the heavy deliveries being made to inland users, and the general tone was consequently very firm. Best large descriptions were moving off steadily. Bituminous smalls were rather better placed, but the dry kinds were in moderate request. Sized brands were difficult to secure and firm.

The Iron and Steel Trade.—Active conditions again ruled in the iron and steel and allied trades of South Wales and Monmouthshire last week. The demand for finished products was maintained, and, with order books well filled, producers generally were assured of steady working for some time to come.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—While the majority of Sheffield trades are now engaged in the production of war material, a high standard of output is being maintained in essential peace-time products, such as agricultural machinery and parts, and tools. The home consumption of these products is very high and export requirements are also increasing. Business with the Colonies and Dominions is considerable. Among the inquiries from overseas are the following: From Jamaica for tools; from Egypt for railway rolling stock, pumping plant, and tools; from Australia, for wrenches; from Venezuela for ironmongery; from Uruguay for steel products generally; from South Africa for tools; and from Northern Ireland for steel pins and implements. Export groups have now been formed for most of the products made in this area, and manufacturers expect the Board of Trade's scheme for the development of export markets to prove successful. A further increase in output is reported by producers of raw and semi-finished materials. Both basic and acid steels are in strong demand. Heavy buyings of scrap are reported, and ample supplies are available. The recent improvement in the demand for ironworks' and steelworks' machinery, and related equipment, has been maintained. Among the latest orders booked are some for rolling mills, hydraulic presses, slab and billet mills, and furnaces of the electric-arc and high-frequency types. There is a better market for gas-fired furnaces for reheating purposes, and makers have well-filled order books. Inquiries at firms specialising in the production of railway rolling stock show that the inland demand is steady, but overseas needs are on the increase. Among the countries ordering are India, New Zealand, South Africa, and Egypt. Sales to South America are better, and prospects in that direction are bright. The special-steel branches are operating at full capacity. There is a prolific demand for stainless steel, and heat- and acid-resisting materials. Manganese steel is in demand in connection with the production of dredger parts and railway and tramway points and crossings. Tool steel is also a progressive section.

South Yorkshire Coal Trade.—The majority of pits in this area are accounting for increased outputs. Industrial coal is in strong demand; some works are buying for stocking purposes. Railway companies are taking increased supplies of locomotive coal, and steam coal is an active medium. Slacks and smalls are in demand by power stations and gas works, and house coal finds a ready market. All types of coke are in demand.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—The aggregate tonnage output of iron and steel on the North East Coast has now reached a very high level and not only is the present make passing rapidly into use but other sources of supply are being called on to cover requirements. Supplies are keeping abrast of the urgent needs of State departments. The usual buyers have substantial ordinary industrial orders to place, but under existing conditions producers of nearly all descriptions of material are giving little attention to general commercial business.

Cleveland Iron Trade.—The supply of foundry iron keeps pace with the gradual increase in demand which is still below the normal. Makers of Cleveland pig have little tonnage on hand and the very moderate intermittent output contributes little towards the steadily expanding requirements of the foundries. As there seems no likelihood of an early improvement in the make of local brands, foundry iron users are becoming increasingly dependent on other iron centres for supplies. Deliveries of Midland products are maintained on a satisfactory scale and adequate parcels of Scotch iron are obtainable for specific purposes. The fixed prices of Cleveland pig are based on No. 3 quality at 120*s.*, delivered within the Tees-side zone.

Hematite.—There is little saleable East Coast hematite and while the present heavy make is sufficient for current needs, consumers would welcome larger deliveries. Buyers are persistently urging producers to furnish increased supplies and the requirements of the makers' own consuming departments continue to grow. Preparations to cope with a further increase in demand are proceeding. The recognised market values are ruled by No. 1 grade of hematite at 131*s.*, delivered to North of England areas.

Basic Iron.—The output of basic iron is sufficient for the requirements of the makers' adjacent steel-producing plants, but provides little tonnage for other purposes. The nominal price is 113*s.*

Foreign Ore.—Stocks of foreign ore are still exceptionally large and imports are continuing on a larger scale than was anticipated.

Blast-Furnace Coke.—Durham blast-furnace coke is plentiful, but sellers have extensive contracts to execute and are not desirous of adding to their delivery obligations; local users have made provision for requirements well ahead, so that transactions are few and small. The stabilised values are ruled by good medium qualities at 33*s.* 5*d.* at the ovens.

Manufactured Iron and Steel.—Ample supplies of semi-finished iron and steel are reaching the re-rolling mills, all of which are operating at full capacity. Finished-iron works are steadily increasing their production and finished-steel plants are operating at high pressure in order to meet urgent demands. Orders in hand for several descriptions of finished material will take some months to execute. Soft-steel billets are quoted at 10*l.* 10*s.* to 10*l.* 15*s.*; hard billets at 11*l.* 17*s.* 6*d.*; joists and angles at 13*l.* 13*s.*; heavy plates at 14*l.* 3*s.*; and boiler plates at 15*l.* 0*s.* 6*d.*

Scrap.—The scrap-collection campaign has substantially increased the supply of iron and steel scrap, but more is still required.

THE FOUNDRY EQUIPMENT GROUP.—The offices of the Foundry Equipment Group and of the Furnace Export Group have been established at Room 242, Grand Buildings, Trafalgar-square, London, W.C.2. The Groups have been recognised by the Board of Trade, and Mr. G. E. France, of Messrs. August's, Limited, Halifax, is chairman, and Mr. K. W. Bridges, secretary, of both the groups.

ELECTRIC-LAMP MANUFACTURE IN NEW ZEALAND.—Messrs. New Zealand Electric Lamp Manufacturers, Limited, have under construction a modern factory for the production of electric lamps at Miramar, Wellington. It is anticipated that production will commence before the end of the present year. The lamps will be made to the standards of the Electric Lamp Manufacturers' Association (of Great Britain) and to relevant British Standard Specifications.

IMPORT LICENCES FOR SULPHURIC ACID.—Applications for import licences for sulphuric acid should be made to the Ministry of Supply, Sulphuric Acid Control, 19, Berkeley-square, Bristol, 8. Application forms may be obtained from the Import Licensing Department, Board of Trade, 25, Southampton Buildings, Chancery-lane, London, W.C.2, or from the offices of H.M. Controllers of Customs and Excise. It is pointed out that the direction at the head of the application form, namely, that it should be forwarded to the Import Licensing Department, should be ignored.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—Scottish steelworks are still running at full capacity. The fact that last week was the usual annual holiday week in the steel-making district made no difference to that industry and work was carried on as usual, except where some small repairs had to be carried out. In the present circumstances, the steel requirements are greater than ever. The steel makers are maintaining an exceptionally large output of both light and heavy material, and consignments of scrap have been coming in very satisfactorily both from overseas and from collections made throughout the country. With the war demands on their present scale, less steel is available for ordinary purposes, and exports are limited. The following are the current prices:—Boiler plates, 15*l.* per ton; ship plates, 14*l.* 3*s.* per ton; sections, 13*l.* 13*s.* per ton; medium plates (rolled in sheet mills), ¼ in. and thicker, 18*l.* 7*s.* 6*d.* per ton; mild-steel black sheets, No. 21 to No. 24 gauge, close annealed, 19*l.* 7*s.* 6*d.* per ton; galvanised, plain, steel sheets, No. 21 to No. 24 gauge, 23*l.* 2*s.* 6*d.* per ton, and galvanised corrugated sheets, No. 24 gauge, 22*l.* 12*s.* 6*d.* per ton.

Malleable-Iron Trade.—Conditions in the West of Scotland malleable-iron trade have not changed and makers continue to be busily employed. The demand for re-rolled steel bars is exceptionally heavy, and although plant is running throughout the whole seven-day week, it is difficult to meet all calls. The supply of semies has been very satisfactory of late, and fairly good stocks are held. To-day's quotations are as follows:—Crown bars, 15*l.* 2*s.* 6*d.* per ton; best iron, 15*l.* per ton; No. 3 bars, 13*l.* 7*s.* 6*d.* per ton; No. 4 bars, 13*l.* 12*s.* 6*d.* per ton; and re-rolled steel bars (tested), 15*l.* 11*s.* 6*d.* per ton, (untested), 15*l.* 8*s.* 6*d.* per ton; angles and tees, 4 in. and under, tested, 15*l.* 1*s.* 6*d.* per ton, and untested, 14*l.* 18*s.* 6*d.* per ton, all for home delivery.

Scottish Pig-Iron Trade.—The production of Scottish pig-iron is being well maintained but, although the furnaces are in continuous commission, the output is barely sufficient to meet the demand. Stocks are low, and there are no accumulations on which to draw, with the result that every ton produced goes rapidly to consumers. Supplies of raw materials are satisfactory, as good deliveries have been coming forward.

COLUMBIUM IN LOW-ALLOY STEELS.—The effect of additions of the order of 1 per cent. to 3 per cent. of columbium on the properties of low-carbon chromium-molybdenum and 0·30 per cent. carbon; 4 per cent. nickel; 1·4 per cent. chromium steels has been studied by the Japanese metallurgists, Messrs. Y. Okura and J. Omori. It is stated in *The Nickel Bulletin* that, as a result of numerous tests, these authors have concluded that columbium is a valuable alloying element in low-alloy steels. They state that it increases strength at high temperatures, enhances resistance to corrosion and oxidation, and improves welding properties; on the other hand, columbium tends to cause a fall in impact resistance and has an inhibiting effect on air-hardening capacity.

ENGINEERING SCHOLARSHIPS AT DURSLEY ENGINEERING WORKS.—Following an examination, held in London last month, in which boys from public and secondary schools took part, Mr. F. M. Turner, of Birkenhead School; Mr. D. A. MacWilliam, of King's College School; and Mr. G. E. Mee, of Chigwell School, have been awarded engineering scholarships, each valued at 600*l.*, by Messrs. R. A. Lister and Company, Limited, Dursley, Gloucestershire. The winners will be given a 4½-years' course of training in the machine shops and drawing offices of the Lister Works at Dursley. During their training, instead of paying premiums as apprentices, they will be paid salaries, which commence at 135*l.* a year, and rise to over 200*l.* per annum. In the past, scholarship apprentices have risen to positions of trust and responsibility by the time they reached the age of 21.

THE H. G. RIDDLE MEMORIAL PRIZE.—An award established by subscriptions among the friends of the late Mr. H. G. Riddle, to commemorate his tenure of the secretaryship of the Junior Institution of Engineers from 1918 to 1939, is open to all members, associate members, associates and students of the Institution. The award will take the form of a prize of books, instruments, tools or materials and will be given for the best paper describing any craft or artistic activity of a scientific nature, allied to engineering, which the author has intensively pursued as an amateur, outside of and independent of his daily avocation, and which shall not have been undertaken for any immediate monetary reward. Normally, one prize will be awarded every three years, and papers must be submitted before March 31 in the year of the award. Further particulars regarding the award may be obtained from the secretary of the Institution, 39, Victoria-street, London, S.W.1.

THE NORTH-SOUTH JUNCTION RAILWAY, BRUSSELS.

(*For Description see page 74.*)

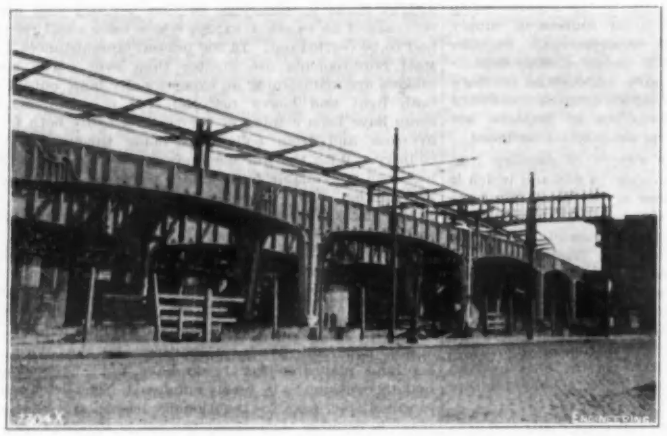


FIG. 20. VIADUCT AT WEST OF SOUTH STATION.

FIG. 21. NEW SIGNAL BOX AT SOUTH STATION.

FIG. 22. AVENUE DE LA REINE BRIDGE.

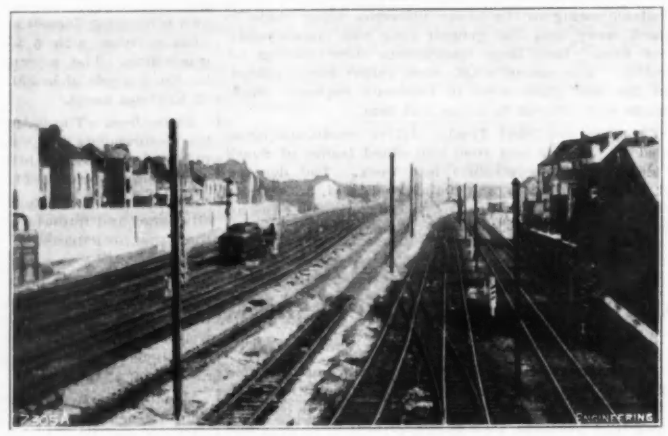


FIG. 23. APPROACH LINES TO NORTH STATION.

FIG. 24. NORTH SECTION OF APPROACH LINES.

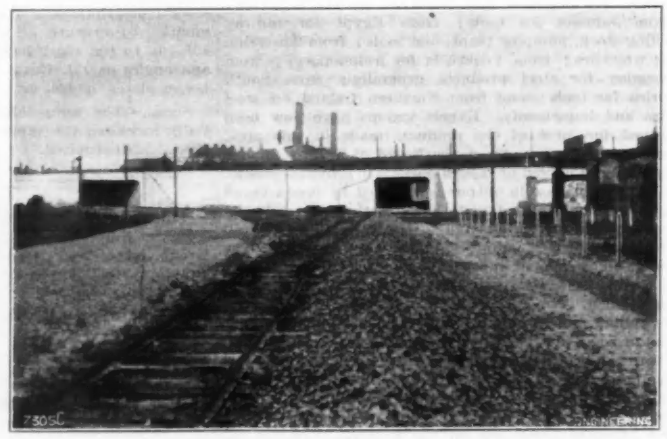


FIG. 25. LAEKEN LINE CROSSING.

MINERAL PRODUCTION IN QUEBEC.—During the first five months of the present year, 130,733 tons of asbestos, 415,964 oz. of gold, and 502,581 oz. of silver were produced in the Province of Quebec, compared with 116,020 tons of asbestos, 409,070 oz. of gold, and 447,390 oz. of silver during the corresponding period of 1939.

INSTITUTION OF ELECTRICAL ENGINEERS.—No other nominations, other than those made by the Council, having been received for the vacancies on the Council of the Institution of Electrical Engineers, which occur on September 30, 1940, the following are deemed to be duly elected: *President*, Mr. J. R. Beard; *Vice-Presidents*, Dr. P. Dunsheath and Major V. Z. de Ferranti; *Honorary Treasurer*, Mr. E. Leete; *Members*, Messrs. H. C. Lamb, F. Lydall, E. B. Moullin, and J. S. Pringle; *Associate Members*, Messrs. H. W. Grimmitt and F. Jervis Smith; *Companion*, Viscount Falmouth.

ENGINEERING HANDBOOKS IN SPANISH.—Messrs. International Engineering Publishing Company, 6, Fitzroy-square, London, W.1, inform us that they have in preparation 22 engineering handbooks in Spanish—*Manuales de Ingenieria*—for sale and distribution in Latin America. The 22 books, each of which will comprise some 150 pages and will be sold at prices ranging from 3 to 5 Argentine pesos, are grouped in three series, namely, civil engineering (containing six handbooks); electrical engineering (containing six handbooks); and mechanical engineering (containing ten handbooks). Each handbook has been specially prepared by leading English engineers in co-operation with eminent South American technical men. The *Manuales*, it is pointed out, will serve the purpose of introducing British practice and furthering British exports in Latin America and Spain, it being stated that the only works of a similar nature in use in Latin America are handbooks in French or Italian, or those issued in English by United States organisations, or the Spanish edition of the German work, *Hütte*, advertising German goods. Publicity matter from British firms will be accepted and manufacturers ipterested are requested to forward their inquiries to the publishers.

THE PORT ARTHUR-ORANGE BRIDGE OVE

(For Description see

FIG. 18. GENERAL VIEW OF CON

Fig. 19.

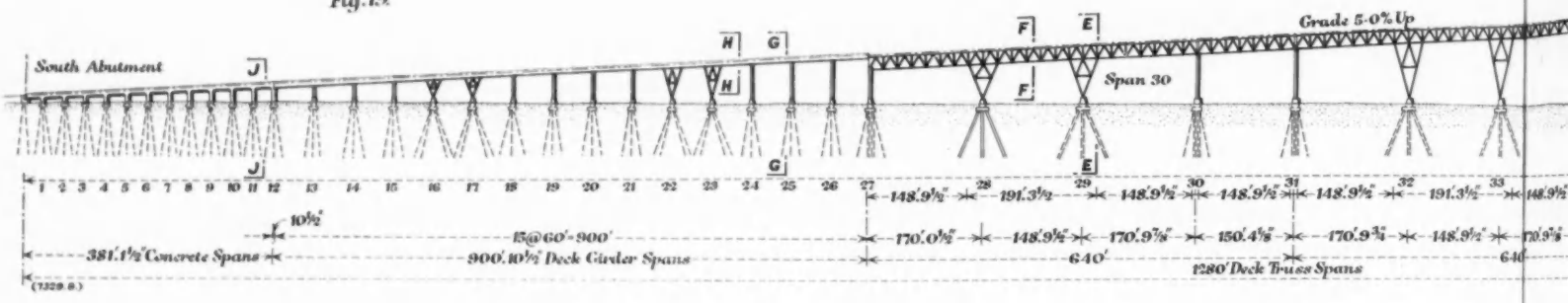


Fig. 20.

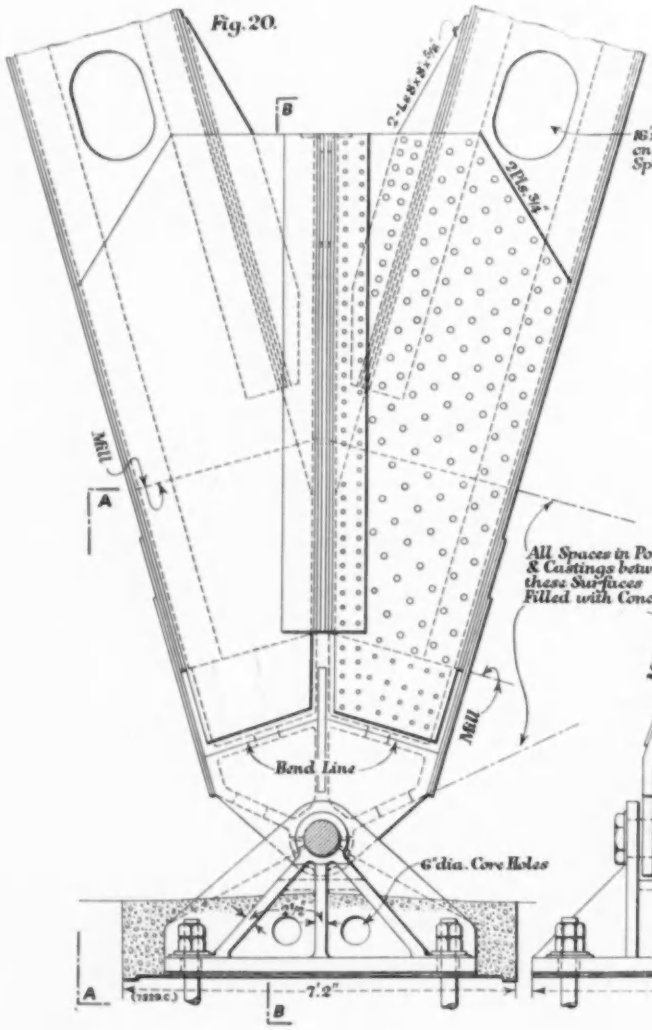


Fig. 23. SECTION CC

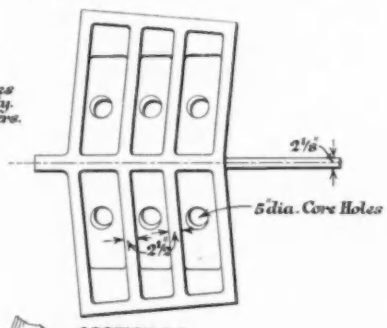


Fig. 21. SECTION AA

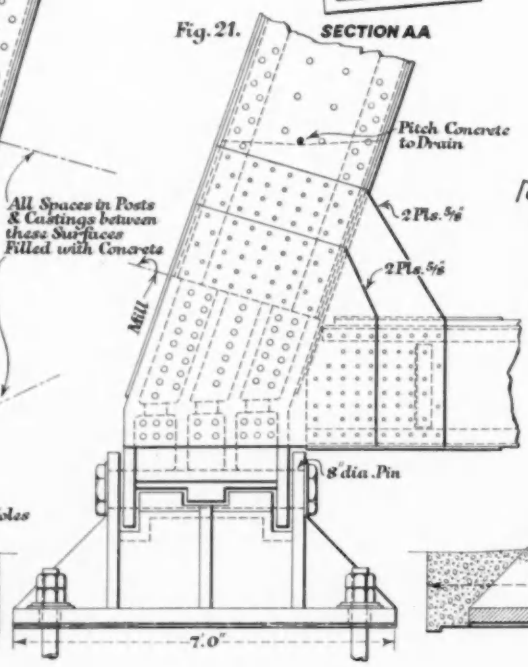
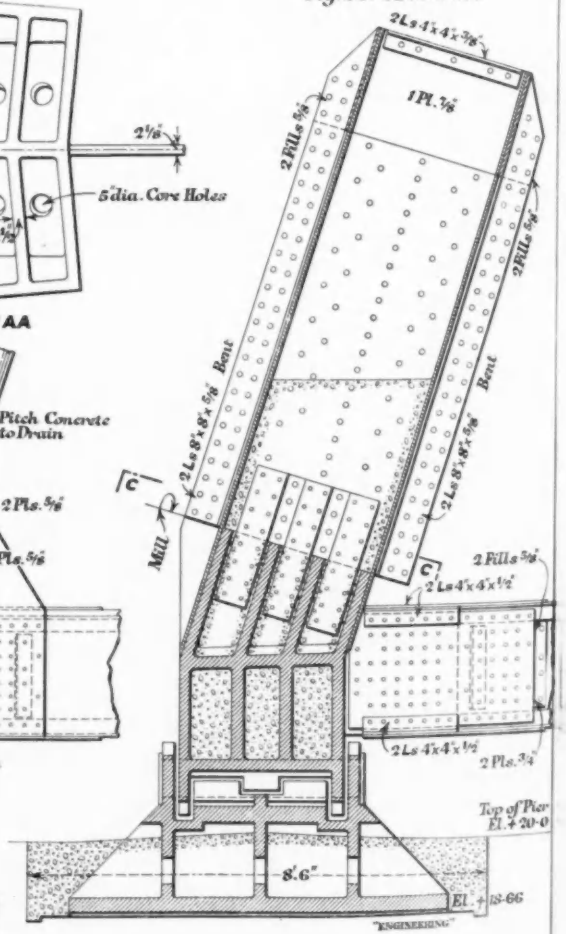
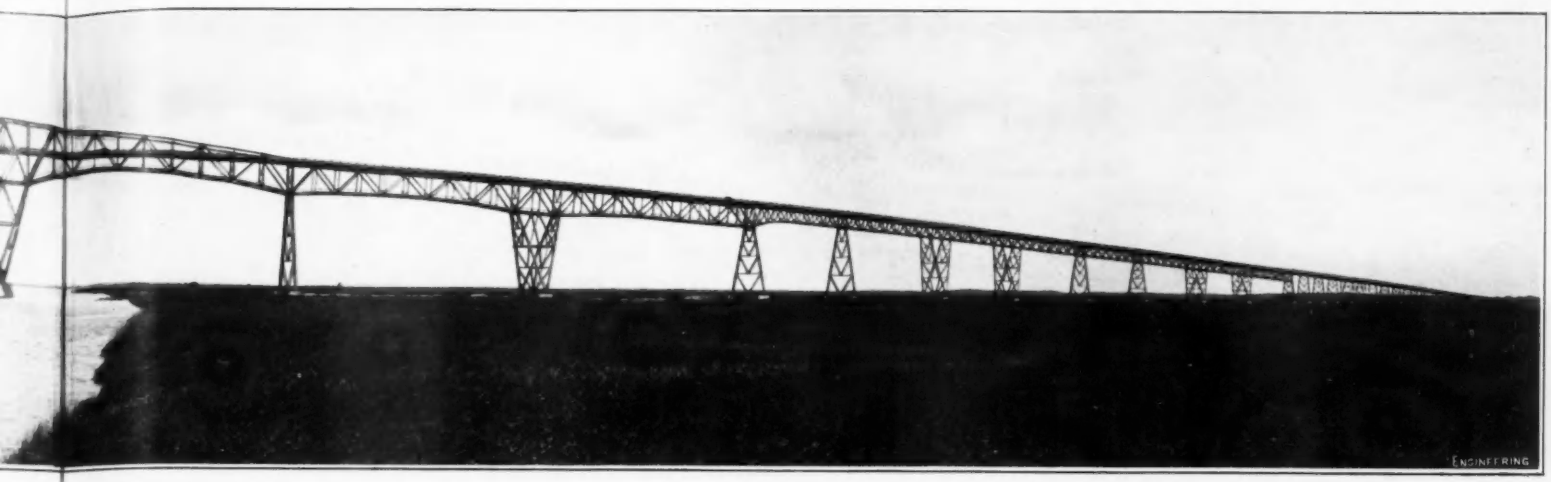


Fig. 22. SECTION BB



E OVER THE NECHES RIVER, TEXAS, U.S.A.

(Description see page 64.)



. View of Completed Structure.

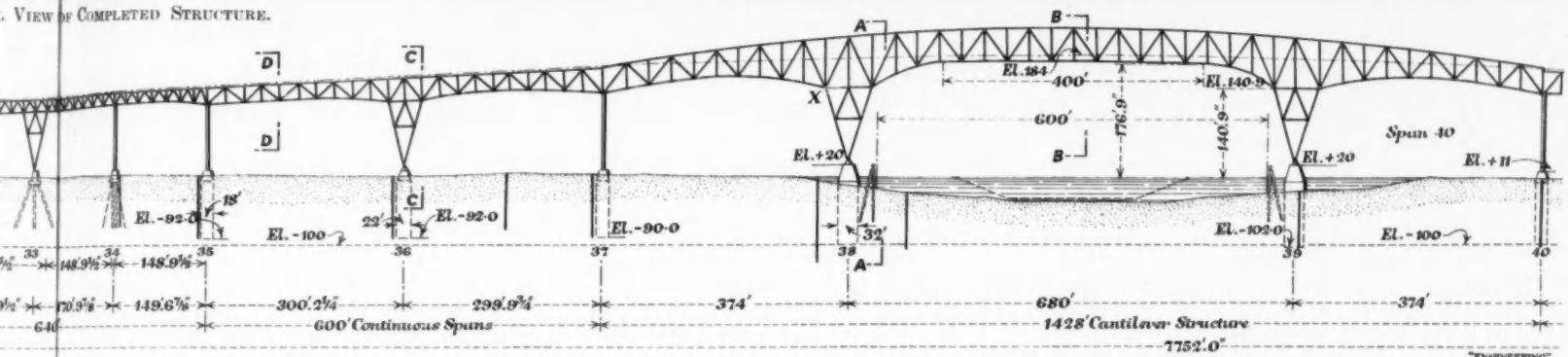


Fig. 24.

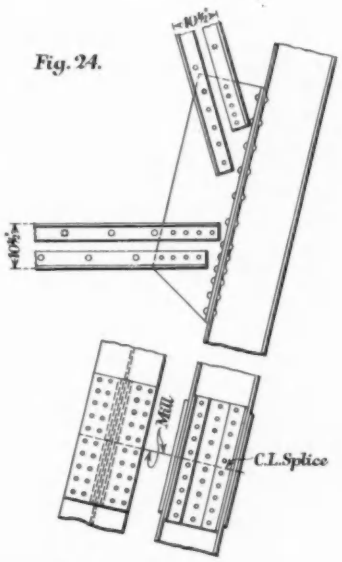


Fig. 25.

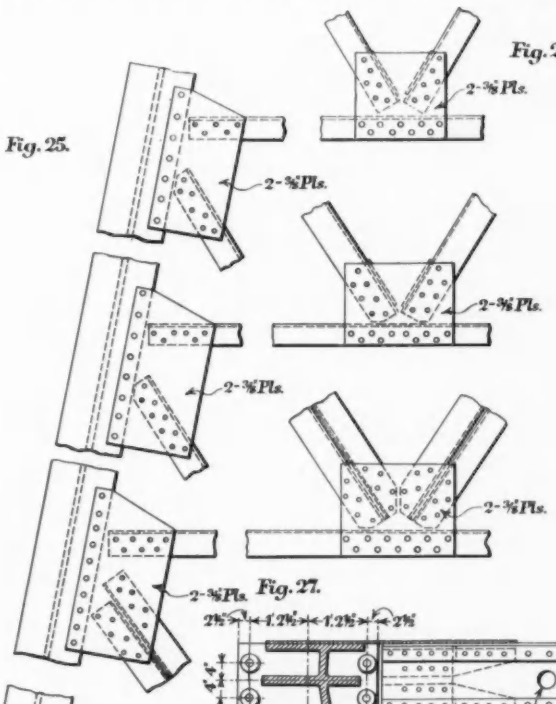


Fig. 29.

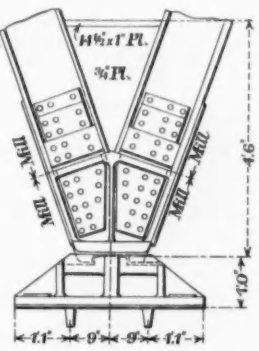


Fig. 30.

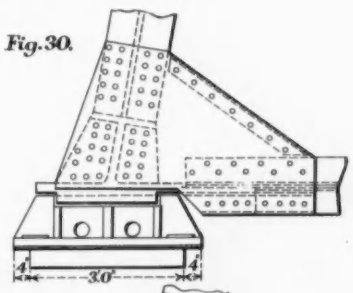


Fig. 27.

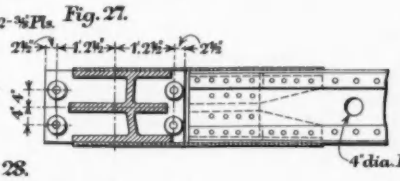


Fig. 28.

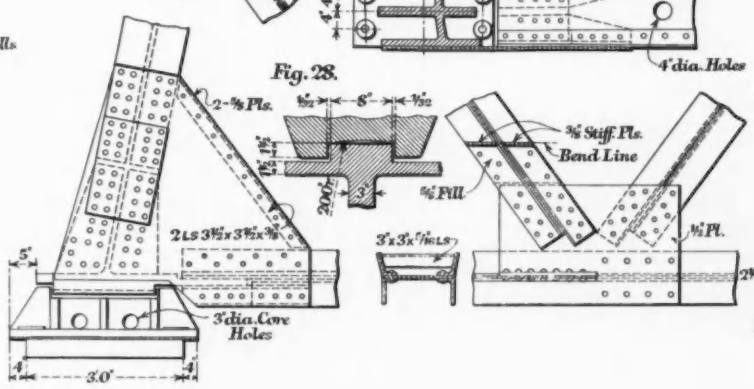
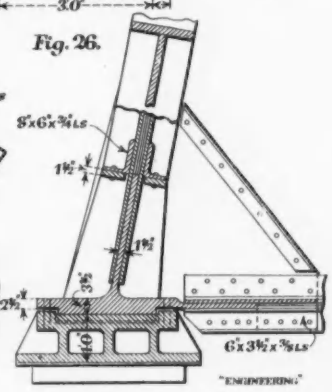
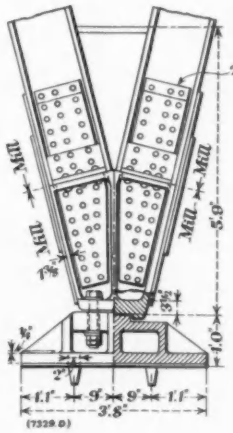


Fig. 26.





UNIV. OF MICH.

ENGINEERING.

Offices for Publication and Advertisements, 35 & 36, Bedford Street, Strand, London, W.C.2.

We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS { "ENGINEERING," LESQUARE LONDON.

TELEPHONE NUMBER—TEMPLE BAR 3663 (2 lines).

SUBSCRIPTIONS, HOME AND FOREIGN.

"ENGINEERING" may be ordered from any newsagent in town and country and at railway bookstalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months (or for six or three months, *pro rata*), payable in advance :—

For the United Kingdom	£3 5 0
For Canada—	
Thin paper copies	£2 18 6
Thick paper copies	£3 3 0
For all other places abroad—	
Thin paper copies	£3 3 0
Thick paper copies	£3 7 6

Foreign and Colonial subscribers receiving incomplete copies through newsagents are requested to communicate the fact to the Publisher, together with the agent's name and address.

When foreign subscriptions are sent by Post Office Orders, advice should be sent to the Publisher.

ADVERTISEMENT RATES.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines, or under, and one shilling per line up to one inch. The line averages six words. When an advertisement measures an inch or more the charge is 12*s.* per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns, of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but cannot be guaranteed.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be delivered not later than first post on Wednesday. Alterations to standing advertisements must be received at least 10 days previous to the day of publication. Passed proofs must be in our hands by Saturday morning, otherwise they will be taken as correct. The Proprietors will not hold themselves responsible for blocks left in their possession for more than two years.

All accounts are payable to "ENGINEERING," Ltd. Cheques should be crossed "The National Provincial Bank, Limited, Charing Cross Branch." Post Office Orders should be made payable at Bedford Street, Strand, W.C.2.

TEMPORARY ADDRESS.

For the duration of hostilities, the Editorial and Publishing business of this Journal is being conducted from 18 and 20, Compton Road, Hayes, Middlesex. The Telephone Number of the Editorial Department is Hayes 1730, and that of the Publishing Department, Hayes 1723. The Bedford Street Offices are open on Fridays only, between 10 a.m. and 5 p.m., for the distribution of the current issue and for retail sales.

INDEX TO VOL. 149.

The Index to Vol. 149 of ENGINEERING (January-June, 1940) is now ready and will be sent to any reader, without charge and postage paid, on application being made to the Publisher. In order to reduce the consumption of paper, no copies of the Index are being distributed, except in response to such applications.

CONTENTS.

	PAGE
Creep Under Combined Tension and Torsion (Illus.)	61
Literature.—Physico-Chemical Methods. Internal-Combustion Engines. Applied Economics for Engineers	63
The Port Arthur-Orange Bridge, Texas, U.S.A. (*Illus.*)	64
Impact Tests on Glass Tiles (*Illus.*)	66
Earthing Practice and Protection from Shock	66
Rotary Filing Machine (*Illus.*)	67
Electrification of the New Pralhad Mill, Bombay	67
The Fire-Resisting Qualities of Linoleum	68
Engineering Training and Education	68
Personal	68
Tenders	68
Notes from the South-West	69
Notes from South Yorkshire	69
Notes from Cleveland and the Northern Counties	69
Notes from the North	69
Training Facilities in War Time	71
The Optimum Week	72
Notes	73
The North-South Junction Railway, Brussels (*Illus.*)	74
Recent Court Cases.—VII	76
Letters to the Editor.—Specific Speed of Pumps and Turbines. Working Hours and Rest Periods	77
The French Aluminium Industry	77
Labour Notes	78
Pneumatic Blow Gun (*Illus.*)	78
Coal Characteristics and Pulverised-Coal Firing	79
Catalogues	80
"ENGINEERING" Patent Record (*Illus.*)	80

One Two-Page Plate.—THE PORT ARTHUR-ORANGE BRIDGE OVER THE NECHES RIVER, TEXAS, U.S.A.

ENGINEERING

FRIDAY, JULY 26, 1940.

VOL. 150. No. 3889.

TRAINING FACILITIES IN WAR TIME.

MORE and more rapidly the full industrial resources of the nation are being brought into active war production, and it is now becoming increasingly evident that the long-term plans, which many were inclined to criticise as being designed on too far-sighted a basis, are being justified by results. One clear indication of the manner in which they are meeting the actual needs of the nation is to be found in the relatively slight dislocation that has resulted from the calling to the colours of the very large number of men who are now under arms or in process of military training. Not all of these recruits to the fighting services have been drawn from the trades which are redundant in time of war, for the maintenance of a highly mechanised army requires that the intake must include an appreciable proportion of men already possessing technical skill of kinds that could find ready employment in munitions production. From time to time appeals have been made for skilled men, to volunteer for particular technical grades in the Navy, Army and Air Force, and there has always been an immediate response ; yet the expansion in munitions production has not been retarded, so far as we are aware, by the enrolment of these men, and although they alone have not been sufficiently numerous to meet all the requirements of the Forces for technicians, it does not appear that the guns, tanks, aircraft and other equipment have had to stand idle for want of men to use and maintain them. These facts, taken together, provide a qualitative measure, if not an accurate quantitative one, of the immense work of training which has been proceeding concurrently with the more spectacular tasks of producing and employing the material. That it should have been possible, at the same time, to carry on with some, at least, of the normal work of technical education is a striking testimony to the capacity for overload and the ability in organisation available in the training establishments of the country.

At the outbreak of war, the technical colleges were about to enrol students for the usual winter sessions, but these plans had to be abandoned at short notice. Within ten days of the declaration of war, however, the Board of Education, recognising the importance of these centres for training purposes, authorised the re-opening of the colleges, even in vulnerable areas. In a number of areas, of course, the mere permission to open did not make opening practicable, as it was essential to make some provision for black-out precautions and air-raid protection. This problem proved to be particularly difficult in London, but by the end of the autumn the colleges were ready to undertake work either for the Services or for industry.

The view taken by the Board of Education before the war, and during its early stages, was that the primary function of the technical colleges must be that of providing training that was directly related to the national war effort ; a view which, there is reason to believe, is still held. In pursuance of this policy, preparations were made to this end, and also, on the industrial side, to meet demands of very varied character, arising out of the special local circumstances of the engineering and allied trades. This took the form, in certain colleges, of providing courses, in co-operation with local firms, for such higher-grade workers as tool-room operatives, tool makers, and tool setters. In other centres, pre-employment courses were established for semi-skilled men, and for forewomen and women operatives. In certain instances, too, the colleges took over the craft training of apprentices, in order to relieve the pressure on local firms which were fully occupied with the problems of a rapidly expanding production. The variety of these training functions, no doubt, explains, in part, the inability of certain colleges to provide immediate instruction or employment for individual volunteers, who were seeking to enrol for purposes not covered at the time by the colleges to which they applied.

In spite of these many activities, however, it was found possible to utilise the college workshops for actual productive work, and, as was announced in ENGINEERING at the time, arrangements were made, in conjunction with the Ministry of Supply, to undertake the manufacture in whole or in part of gauges and other suitable components, on a basis that would enable the available plant to be employed to its fullest capacity. The labour now employed on this very useful work has been recruited almost entirely from sources other than industry, in order to avoid withdrawing skilled personnel from manufacturing firms. Numbers of handicraft teachers have been transferred from elementary and secondary schools, either to act as instructors or to work themselves on production. Retired engineers and other volunteers have also come forward, and an appreciable amount of work has been done by students, both full-time and part-time. It is satisfactory to note that it has been found possible to employ a considerable proportion of part-time volunteers on this work : a course that we have advocated on more than one occasion when discussing the expansion of war effort. From the general particulars that have been released from time to time regarding the training establishments of the Services, it is evident that these have been considerably extended and it may be supposed that, in time, they will have no further occasion for assistance in training their own technicians. The whole resources of the technical colleges will then be available for increasing the flow of trainees into industry.

It will be seen from the foregoing outline of the training facilities and organisation that there should be a rapid and cumulative benefit to the munitions output from the steadily growing force of trained men and women into the factories ; and that, simultaneously, the regular technical education of those apprentices and other youths, who intend to make their living in the engineering industry and profession, is not being overlooked. The arrangements for calling up young men for military service provided certain safeguards for those who are engaged in regular courses of engineering instruction, leading to recognised qualifying examinations, so that they should not lose the advantage of work already done. These concessions, however, do not touch the case of the many youths who were still at public or secondary schools when war broke out, and who are now approaching the age when, in

normal circumstances, they would be entering Woolwich or Sandhurst, or proceeding to a university, with the intention of making engineering their career. The certainty that they will be called up for service with the Forces on reaching military age prevents them from embarking on any long-term course of higher education or apprenticeship, and the peace-time method of entry into the Army through Woolwich and Sandhurst is suspended, of course, for the duration of hostilities.

The widespread nature of this difficulty, and the fact that the numbers affected were increasing rapidly as successive batches of boys reached school-leaving age, have caused special consideration to be given to the problem by the Institution of Mechanical Engineers. As the outcome of consultations with the Directorate of Military Training, in conjunction with the Public Schools Employment Bureau, a scheme has been prepared which should have the effect of providing such boys with a sound groundwork of engineering workshop training, which cannot fail to prove an asset in fitting a boy for eventual service with a technical unit of the Forces. We understand that the scheme has the approval of the Ministry of Labour and National Service and that a similar scheme is being arranged by the Institution of Electrical Engineers. The basis of the scheme prepared by the Institution of Mechanical Engineers was the offer, by various engineering firms with which the Institution was in close contact, to provide employment involving a certain amount of engineering training to a limited number of boys between the time of leaving school and their attainment of military age. As the preparations have now reached the stage when the scheme can be put into practical operation, some particulars of its scope can be given.

The point is stressed that the scheme does not conflict with or supersede any established scheme for regular engineering apprenticeship, nor is it to be regarded as an avenue into a "reserved occupation": it is primarily designed to fill the time interval between school and military service by providing training which, while necessarily limited in character, will represent useful productive work in the national interest, a preparation for technical service with the Forces, and knowledge which will be of direct benefit to the individual when he is able to resume his civilian status. By arrangement with the schools, boys put forward under the scheme will be those who have already shown some scientific bent; and, normally, they will have gained the School Certificate, in either the ordinary or the higher grade. During their training, they will be encouraged to enter upon a part-time course of study, if possible for the Ordinary National Certificate. A qualification of this standard is likely to be a definite asset on entering the Services and might materially influence subsequent selection for commissions; and, of course, it would greatly facilitate the resumption of engineering training after the war. Any boy accepted by an engineering firm under the scheme, who may show exceptional promise, could be transferred to a regular apprenticeship scheme if this were desired; but, it should be repeated, this is not the primary object.

The boys accepted will be termed "special engineering trainees"; and, to comply with the requirements of the Undertakings (Restriction on Engagement) Order, 1940, arrangements will be made to submit apparently suitable candidates through the Local Office of the Ministry of Labour at 4, Great Marlborough-street, London, W.1. In most cases, if not all, it is expected that the firms concerned will pay a small wage which will enable the boys to be self-supporting to a certain extent. Particulars of the scheme, and that of the Institution of Electrical Engineers, are being circulated to all public and secondary schools, with lists of the firms which are willing to accept boys under the stated conditions. It may be that detail modifications may suggest themselves when the scheme has been in active operation for some time. In principle, however, it may be commended as a practical solution to a problem which has been causing some concern to parents, as we have reason to know from various inquiries that have reached this office; and, from the national point of view, as a valuable addition to the existing facilities for providing technical training.

THE OPTIMUM WEEK.

No matter what may come, the manner in which the British Expeditionary Force extricated itself from the critical situation in which it was left by the capitulation of the Belgian army will remain one of the major military achievements of the war. Its first duty was to save itself from destruction in order that it might in due course take effective action against the enemy, unhampered by dictates over which it had no control. The fact that success was achieved only with the loss of its matériel did not dim the brilliance of the military action, but it did create a serious situation from the point of view of the necessary re-equipment. The manner in which the munition manufacturers and their workpeople girded themselves to replace the loss was an achievement which, in its own sphere, may be set alongside the military operation itself. Both performances represented concentrated efforts which it is not humanly possible to make continuously. The army is now rested and reconditioned, and the time has come when the munition workers, their immediate task accomplished, may adjust their effort to a tempo which it will be possible to sustain over the long months to come.

No one, we imagine, supposed—certainly, we did not—that the workpeople and the management staffs would be able to sustain a seven-day week indefinitely, although in a vital emergency they could and would forgo their Sunday rest for such time as was necessary to transform a situation of acute danger into one of relative security. In dealing with this matter, we have on two occasions criticised a recent report produced by the Industrial Health Research Board. They are referred to in a letter from Dr. H. M. Vernon which appears on page 77. The justification of our criticism of a particular case quoted in that report would appear to be confirmed by Dr. Vernon's information that the report is misleading; but his statement that we "deprecate a general Sunday holiday" we cannot admit. In both articles we were dealing with an emergency policy, not with a long-period one, and so, far from apologising for it, must repeat our statement that, at a time when the supply of munitions was a matter of life or death, to put forward the bald assertion, supported by no adequate evidence, that "the Sunday rest and ordinary holidays should not be interfered with" was indeed nothing less than mischievous.

The effort which has been made is now beginning to earn its reward, and, speaking at a lunch arranged by the British Federation of Business and Professional Women on July 17, Mr. Bevin, the Minister of Labour and National Service, announced that, from August 1, the Factory Acts would again be brought into operation to limit the hours of work of women and young persons. Women in the munition factories, particularly the large numbers who are new to the conditions of an engineering shop, must receive first consideration in any easing of conditions which is possible. This is necessary not only for their welfare, but also if maximum output is to be obtained. Mr. Bevin said that, under the new regime, he hoped to maintain seven-day production; as he added, however, that there was still a great shortage of skilled men, it does not appear that the employees on whose shoulders the carrying on of industry really rests are likely to share at present in any radical easing of the strain. This must apply particularly to shop managers and head foremen. In the general discussion of this subject, attention is usually confined entirely to the workpeople, but those who direct their activities are subjected to an even greater strain, and it would be not only unfair, but unprofitable, to overlook their claims in any adjustment of hours which the future may show to be practicable. The distribution of responsibility is such that many departmental managers find it necessary to attend during the whole of the seven-day week which is now being worked. Incidentally, in this connection, it would be well if some consideration could be given to the claims of senior officials in the Civil Service, and by some method of delegating authority, permit them some relief.

The Minister's speech showed that he has a clear understanding of the conditions now ruling. An enormous extension of the labour force of the engineering industry can be accomplished only by a parallel extension of the skilled staffs which direct it. Had he the right number of men and women to fill key posts, said Mr. Bevin, he could put another quarter of a million women into work immediately; but those key employees are not available, and as increased production is still the paramount consideration, it does not appear probable that skilled labour is yet likely to achieve the type of optimum week about which Dr. Vernon writes. With the essential basis of his contention, that excessive hours will ultimately result in reduced output, we are in entire agreement; but if his opinion is that the optimum week of peace time should willy-nilly be adopted in the throes of a desperate war, then we must express dissent. Mr. Bevin said earlier that he was endeavouring to arrange that all workers shall have one day off each week. This is the present practice in the Civil Service and is probably the best that can be hoped for.

Although it might be a comforting self-persuasion, that in some few months industry may so adjust its shop procedure that everyone concerned can have a full week-end off, it would be both useless and foolish to think so. For pure repetition work and with an adequate supply of labour, enabling multiple shifts to be worked, it is possible that a stage may be reached in which a nice balance can be struck between output and hours, with some approach to a peace-time optimum week. For really skilled work, however, for which the supply of available labour is and will remain limited, the outlook is very different. A six-day week is the best that can be hoped for until freedom can once more raise its flag on the Continent. This, however, is no reason for not relieving skilled labour from all work that can be done by others. Many of those who have passed through, or are passing through, the Government Training Centres should develop in due course into competent machinists or be capable of taking the place of a tradesman in controlling the setting-up of banks of machines. These and other unskilled workers who show the ability should be capable eventually of acting as foremen and so freeing men of wider experience and skill for more difficult work. Much aid may also be expected from women workers. Mr. Bevin referred to skilled women in his speech and, although in normal life the skill of women is directed to quite other ends than the production of lethal weapons, many of those now in the shops, or undergoing training, should be able, in due course, to carry out duties which are normally looked upon as those of a skilled man. One system for training women to a stage enabling them to take over certain skilled duties was described in our issue of April 19.

That the importance of grading up is realised in ministerial circles is made evident by the letter signed by the First Lord of the Admiralty, the Minister of Supply, and the Minister of Aircraft Production, which was addressed, last week, to 9,000 firms engaged on war production. It points out that, although the Government training schemes have been expanded, and will be expanded still further, they will by no means be able to meet the whole of the needs of industry and that further training—indeed "the greater part of training"—must be undertaken by employers themselves in their own workshops. In view of this need, employers are asked to introduce or to increase training facilities, not only for new entrants, but to enable existing employees to be graded up to a higher standard. This procedure will release skilled men, now engaged on the class of work demanding lesser skill, to be transferred to operations which are beyond the capacity of trainees, their previous jobs being taken over by those who have passed through the training departments. The letter also refers to the "breaking down" of operations so that jobs can be done by workers of less skill. This process is not new. It is the basis of all repetition manufacture. Its extensive application in new lines of work may demand considerable time and the preparation of large stocks of jigs and special gauges; none the less, it is the only method by which complicated and accurate mechanisms can be produced by semi-skilled labour.

NOTES.

THE EMPIRE NAVIES IN ACTION.

WITH the brilliant little action in the Mediterranean on July 19, when H.M.A.S. Sydney and her accompanying destroyers sank the Italian light cruiser Bartolomeo Colleoni, yet another of the Empire's navies has effectively demonstrated its quality as a fighting force under modern conditions of naval warfare. New Zealand's navy had the first opportunity to achieve distinction in action during the present war, and the Achilles took full advantage of it in the running fight with the Graf Spee. Comparatively little was heard of the Canadian Navy in official communiques until June, when it was revealed that the First Lord of the Admiralty had paid a visit to "the destroyers of the Royal Canadian Navy now co-operating with the Royal Navy in home waters." Rather less than a month later, the First Lord had to announce the loss of one of these destroyers, the Fraser, "sunk in the face of the enemy during operations off the coast of France." Even the Royal Indian Navy, though hardly designed as a fighting force, has had a taste of enemy action, having lost the escort vessel Pathan by mines. There is a particular satisfaction in recording the exploit of H.M.A.S. Sydney, however, by reason of the part played by her predecessor of the same name in sinking the commerce-raider Emden in 1914. Incidentally, there must be some heartburning in the Royal Australian Navy now, that the captured bell of the Emden was officially returned to Germany some years ago, as a gesture of goodwill. On paper, the new Sydney was considerably overmatched in comparison with the two Italian cruisers, each of which carried approximately the same armament as herself; but the escorting British destroyers, the number of which has not been stated, must have been able to bring a useful fire power to bear at any moderate range, and the Sydney had the advantage of better armour protection than the enemy vessels. The Italian cruisers, however, though of some 1,800 tons less displacement than the Sydney, had at least 20 per cent. more horsepower and correspondingly greater speed; and it is a tribute to the gunnery training of the Royal Australian Navy that good shooting was able to nullify this advantage at an early stage and so enable the British ships to close in and sink the Bartolomeo Colleoni. The fact that the Italian official account of the action stated that there were two British cruisers engaged suggests that immediate measures were deemed necessary to counter the tales brought back by the ship's company of the Giovanni delle Bande Nere, the cruiser which succeeded in making good her escape.

INVENTORS IN WAR TIME.

It has been said that the principles of strategy do not change, which means, presumably, that Hitler will be beaten by the observance of the same rules as those by which Marlborough overcame Louis XIV, to go no farther back into the world's history. While, however, that great soldier, according to the Prime Minister's biography of his ancestor, had many obstacles to overcome before he achieved victory, he at least was not exposed to any great extent to one, perhaps minor, infliction, which troubles our naval and military hierarchy in these mechanical days; namely, the genius who produces innumerable inventions which, on paper at least, cannot fail to bring the enemy to his knees in an incredibly short time. The trouble, of course, is that not all these schemes are worthless, so that the responsible investigators are taking grave risks if they dismiss any of them without careful examination. Nevertheless, inventors, who are notoriously bad exponents of their own cases, cause a great deal of time to be wasted in separating what is valueless (the larger proportion) from what may contain at least the germ of some useful idea. Those who conduct the affairs of technical journals are exposed to the same sort of dilemma and we can appreciate the exasperation, to put it no stronger, which the importunities of some of these gentlemen must cause to the authorities. At the same time, we are glad to learn from the Prime Minister, last week, that it is the duty of the various departments connected with the prosecution of the war to consider carefully the immense number of suggestions that are received. He believed that, on the whole, considering the extreme pressure of the times, this work was being well done by the research branches. He also deprecated the idea that scientists at the disposal of the Government were tied by preconceived notions and added that the Admiralty had succeeded in discovering an antidote to one menace, before they were able to deal with the correspondence about it. There was no lack of willingness to adopt new ideas, and suggestions were not unwelcome.

ROAD ACCIDENTS.

During last June, 479 people were killed on the roads of Great Britain, compared with 493 during the corresponding month of last year. Of these deaths, 92 occurred during the black-out. This reduction represents only 2·8 per cent. and is the more extraordinary since the traffic has fallen off in very much greater proportion. It would, therefore, appear that, as some have always contended, that it is not the volume of the traffic but its speed, and the care or otherwise with which the various vehicles are driven or avoided, that decides the issue. This conclusion is supported by the fact that the speed of vehicles, especially those of the commercial variety and in built-up areas, is much higher than it should be, while there is a greater tendency to take risks and more laxity in giving the essential signals than there was twelve months ago owing to the less density of the traffic. Laxity, however, is not the sole prerogative of the driver and there is also no doubt that the reduced volume of traffic has tempted both pedestrians and cyclists to take greater liberties than they would have thought wise last year. This is shown by the fact that of the fatalities, 120 were pedestrians and 90 cyclists, while, in addition, 63 child pedestrians were killed and 17 child cyclists. Car drivers themselves came off comparatively lightly, only 28 suffering fatal injuries, but 91 motor cyclists were killed and five pillion passengers. It is, therefore, clear that though the war has pushed this particular problem into the background, it has not solved it.

THE MIRRLEES WATSON COMPANY, 1840-1940.

The war has interferred with the due observance of a number of interesting centenaries, for the period around 1840 was one of considerable engineering expansion. Among the businesses founded in that year was a partnership of three brothers, Peter, William and Andrew McOnie, trading as P. and W. McOnie, engineers and millwrights, the forerunners of the present firm of The Mirrlees Watson Company, Limited, of Glasgow, and its associated undertaking, Mirrlees Bickerton and Day, Limited, of Stockport. Mr. (afterwards Sir) William McOnie retired in 1848 and Mr. J. B. Mirrlees then became a partner, the name of the firm becoming McOnie and Mirrlees. When Peter McOnie died, three years later, Mr. Mirrlees appointed as manager William Tait, who came from Neilson and Company and who, in 1858, was taken into partnership. The firm traded as Mirrlees and Tait until 1868, when Mr. (later Sir) W. Renny Watson joined the partnership. The name then became Mirrlees Tait and Watson, a title which was retained until 1882. During this period the firm acquired from David McColley Weston, of Boston, U.S.A., the rights in various sugar-machinery patents, including the suspended and pivoted oscillating centrifugal machines, and it was to develop this side of the business that a new works was built in 1883, with Mr. John Laidlaw as managing director, and operated as Watson Laidlaw and Company. On the admission to partnership of Mr. R. A. Robertson and Mr. J. G. Hudson, in 1882, the parent concern became Mirrlees Watson and Company, a further change to the Mirrlees Watson and Yaryan Company, Limited, taking place in 1889, when the rights were acquired of the evaporating apparatus devised by Mr. Homer T. Yaryan, which still forms an important section of the regular output. In 1896, a historic development took place, when an exclusive licence was obtained for the manufacture and sale of Dr. Diesel's heavy-oil internal-combustion engines. The first engine was completed in 1898, but the difficulties encountered proved a heavy drain on the company's resources and, a year later, the exclusive licence was sold back to the Dieselmotoren Company, of Augsburg. In 1899, also, the company was reconstructed under the title which it still bears. In 1900, Mr. Charles Day (now chairman of the company) became manager and rapidly developed the production of oil engines. To cope with the increasing demand, a new works was erected in 1907 at Hazel Grove, Stockport, and a separate company formed, which is still known under its original title of Mirrlees Bickerton and Day, Limited. Mr. Day was managing director of both companies, which were amalgamated in 1926. In addition to their sugar machinery, the two firms have been associated with a number of outstanding developments in steam engineering, among which may be mentioned the Stirling boiler, the Edwards air pump, the Leblanc rotary air pump and the Delas condenser. During its hundred years of active production, it is computed, the Mirrlees Watson Company has constructed 119 two-roller crushers and 2,162 cane mills of all sizes, together with the necessary driving machinery and other sugar-factory plant.

THE CITY AND GUILDS OF LONDON INSTITUTE.

In spite of the conditions ruling, the City and Guilds of London Institute, in its accounts for the year ended December 31, 1939, has been able to show an excess of income over expenditure of 1,114*l*., as compared with 1,661*l*. at the corresponding date in 1938. The City and Guilds College showed an excess of expenditure over income of 673*l*., a small sum for an organisation having a total income of 70,986*l*. These figures are given in the report for the year 1939 and it is possible that, when a balance has to be struck at the end of 1940, less favourable results will appear; but the Institute and its associated College have undoubtedly benefited from the courageous policy of continuing work, and, as there appears to be no intention of abandoning that procedure, it may be that financially, as well as in other directions, they will continue to prosper. The work of the Department of Technology of the Institute is of particular importance at the present time, when it is so desirable that the technical education of young artisans and craftsmen should be maintained at a satisfactory level of efficiency. Last year, examinations in technological subjects and for teachers' certificates were held in 556 centres in Great Britain and Ireland, and in 121 cities overseas. Of 40,471 candidates who took these examinations, 38,189 entered for technological subjects, an increase of 14·5 per cent. over 1938. The increases in the number of examinees were mainly in Telecommunications, Electrical Engineering Practice, Textiles and Mechanical Engineering. India and Malaya furnished two-thirds of the candidates in overseas centres. The syllabuses for 126 subjects, out of 140 in the Department's programme, have been amended or are newly introduced. This revision has attracted increasing numbers of candidates, especially in Machine-Shop Engineering, the Motor-Vehicle Mechanics' and Electricians' Courses, and Welding. It is proposed to carry on these examinations as far as possible this year, certain modifications being made in connection with practical tests and the submission of specimen work. In the portion of the report dealing with the City and Guilds College, it is stated that 105 students entered for the Final (Internal) B.Sc. (Engineering) degree examination of the University of London. Of these, 87 passed, 14 taking First-Class Honours and 32 Second-Class Honours. The appointment of Dr. H. Heywood to the post of Assistant Professor and Reader in Mechanical Engineering in the college is also recorded. Dr. Heywood succeeds Dr. S. L. Smith, who has been appointed superintendent of the Engineering Department of the National Physical Laboratory. Dr. A. P. M. Fleming has been appointed a member of the governing body in place of the late Mr. W. M. Mordey. The chairmanshp of the Council of the Institute, rendered vacant by the death of Sir William Pope, has been accepted by Professor R. S. Hutton.

THE NORTH-SOUTH JUNCTION RAILWAY, BRUSSELS.

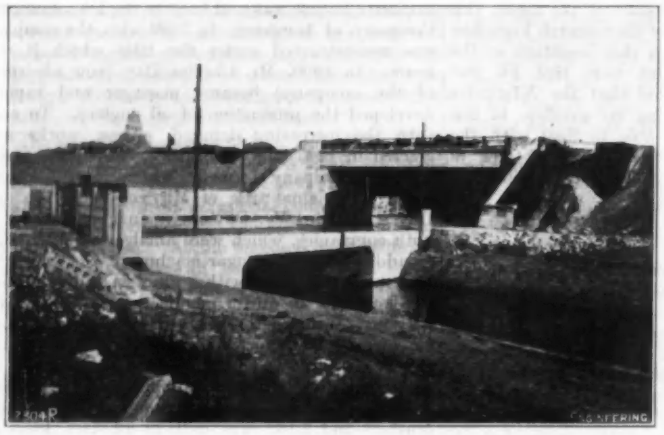


FIG. 26. BRIDGE OVER RUE THÉODORE VERHAEGEN.

FIG. 27. MARSHALLING YARD AT VORST.

THE NORTH-SOUTH JUNCTION RAILWAY, BRUSSELS.

(*Concluded from page* 22.)

REBUILDING OF THE SOUTH STATION.

As shown in Fig. 8, page 15, *ante*, the South station is situated between the Avenue Fonsny and the Rue de France, the present façade, illustrated in Fig. 1, on page 10, *ante*, being situated in the Rue d'Argonne. As already explained, to convert this terminal station into a through station it is necessary to raise the whole of the area covered, by 6 m. Incidentally, this raising of the station will have the advantage of considerably improving the road communications between the districts of St. Gilles and Anderlecht, which lie respectively to the east and west of the railway track, south of the station. The bridge carrying the railway at its new level over the Rue Théodore Verhaegen, which lies outside the map reproduced in Fig. 8, is illustrated in Fig. 26, on this page. Before the alteration, this road came to a dead end at the railway. Fig. 26 also shows the new bridge over the River Zenne. The old station had 20 railway tracks. The new will have 22, of which four will be terminal tracks and the remaining 18 will make connection to the six tracks of the junction railway. The platforms, which at present extend almost up to the station buildings, leaving a very small circulating area, will be moved about 150 m. to the south.

It has been necessary to provide an entirely new marshalling yard and locomotive shed in connection with the new works. The old shed was situated in a rather cramped position between the line to Ghent and the western ring-line, which are shown in Fig. 7, page 14, *ante*. The new accommodation is situated at Vorst, 4 km. south of the station. The new yard, which contains a shed capable of accommodating 150 locomotives, a 300-cub. m. overhead coal bunker, a 300-cub. m. water tower, inspection pits, turntables and other accessories, is illustrated in Fig. 27. It has been in commission since December, 1938. The whole of the track and other work involved in the alterations has been practically completed up to a point 2 km. south of the station. It was necessary to have the whole of the new marshalling arrangements in working order before the difficult work of raising and reconstructing the station was put in hand. The new level resulting from the raising of the station area begins at a point 1 km. south of the station.

The raising of the station is being carried out in a series of strips extending for its full length. A start has been made on the west side over a space occupied by a number of tracks of minor importance, additional width being obtained by the canalisation of the River Zenne in the manner shown in Fig. 26, thus confining it within a narrower area. This new section of the station is carried on four steel viaducts, each 200 m. long. These are of the type illustrated in Fig. 20, page 70, and Fig. 28, opposite. Three of the viaducts each carry two railway tracks, the other accommodating one only. They are connected by cross-girders, as shown in Fig. 28. These girders will carry the station platforms. As will be seen from these two figures, the viaducts consist of a series of rigid steel frames built up from plates and sections and each consisting of four legs and their connecting span. These members have cantilever extensions, which carry the intermediate spans. The whole of this steelwork is electrically-welded. Rocker joints are provided at the bases of the legs, the foundation plates being carried on concrete blocks supported on piles. The tracks above the viaducts will be supported on rubble beds carried by a steel decking. The space below the viaducts and cross-girders will form a goods shed at ground level. Fig. 20 shows the side of this shed fronting on to the Rue de France, but when the station is completed this face will be covered by the western façade of the building.

This first section of the reconstructed station, it is understood, will be opened shortly, and the necessary track connections are being made by which the new platforms can handle traffic from any of the lines entering the South Station, as shown in Fig. 7, page 14, *ante*, except the line to Charleroi. The roof on the most westerly platform under construction can be seen in Fig. 20. The traffic will be handled from a new signal box built alongside the Rue de France and illustrated in Fig. 21, page 70. This box, which will ultimately deal with the whole of the traffic of the reconstructed station, is the largest in Belgium. Daylight light signals and electrically-operated switches are being used throughout the new installation. When this new section of the station is in full operation, the raising and rebuilding of a second strip, alongside it, will be taken in hand. This second strip will be in line with the bridge over the Rue Théodore Verhaegen, which is shown in Fig. 26. For this second section, the tipping of earth to raise the level of the area will be carried out more conveniently, as it will be possible to tip sideways from the line alongside, which has already been raised to the new level. When the second strip has been completed, a third will be taken in hand and so on until the work has been carried to the Avenue Fonsny, on the east side.

The railway tracks in the reconstructed part of the station are at present all terminal tracks and end at a point south of the termination of the old tracks. The new station building will occupy part of the space now taken up by the old lines, where they extend beyond this new position. The new building will be of horse-shoe form with the main entrance in the Rue de France and the main exit in the Avenue Fonsny. A passage 20 m. wide and at ground level will connect the two sides of the station. It will contain the booking offices, waiting rooms and other accommodation for passengers and will be connected to the platforms by stairs and escalators. There will be a second through passage for vehicles and on the north side a covered way from which passengers can board trams and omnibuses without going into the open. In connection with the reconstruction of the station it may be said that the architectural features of the shops under the partially-constructed viaduct, to be seen to the right of Fig. 1, page 10, *ante*, will be modified to correspond with the new building. This gallery of shops was in existence in 1914, and since that time has been waiting for the completion of the viaduct above.

REBUILDING OF THE NORTH STATION.

The lay-out of the North Station is generally similar to that of the South Station and the same method of reconstruction has been adopted. There are sixteen railway tracks in the old station, but these are being reduced to twelve in the new structure; all will be through tracks with connection to the junction railway. Various local conditions will complicate the carrying out of the work. Two connections only exist between the districts situated on the two sides of the large area occupied by the station and its approach lines. One of these is a bridge carrying the Avenue de la Reine over the railway; the other is a subway for pedestrians at the Rue Allard. The Avenue de la Reine and the Rue Allard are outside the limits of the map given in Fig. 8, page 15, *ante*. The next connecting way across the railway is the Teichman Bridge, near Schaarbeek Station, and more than 2 km. from the North Station. In these circumstances it was not possible to contemplate any method of working which would put the Avenue de la Reine bridge out of commission. Further difficulty is introduced by the existence of the railway track joining Laeken to the Leopold Quarter and which crosses the lines leading from the North Station. This line is indicated in Fig. 7, on page 14, *ante*. A further matter which had to be arranged for was the moving of the electrified tracks, which serve the Antwerp line, to the east side of the station.

The reconstruction and raising of the station and of its approach lines is being carried out in strips in the same way as at the South Station. Each strip is divided into north and south sections, the Avenue de la Reine bridge, which is illustrated in Fig. 22, page 70, forming the boundary between them. Work north of the bridge is to be put in hand first. This includes building two bridges to take the Rue des Palais and the Paviljoen Straat under the railway. These roads, approaching from the east, converge close to the railway so that the western abutments of the two bridges form a common structure. These bridges will carry ten tracks, as compared with the original eight for this section of the railway. There will be two lines serving the Ghent connection, two for the Liége line, two for Namur, two electrified lines to Antwerp, and two service lines. A view of this section of the railway is given in Fig. 23, on page 70. The lines

NORTH-SOUTH JUNCTION RAILWAY, BRUSSELS.

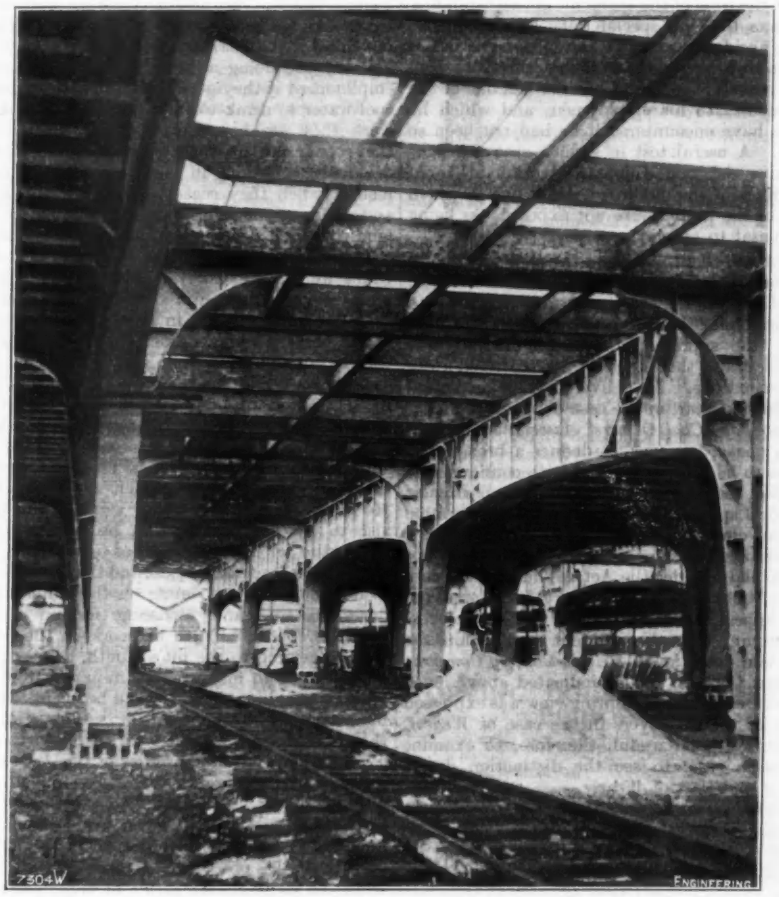


FIG. 28. VIADUCTS CARRYING SOUTH STATION.

on the extreme left next to the new retaining wall and already raised to their new position are those serving the Ghent connection; the double track next to these is the Liége line; the tracks still to be raised are to Namur connections and the electric lines to Antwerp. Although the new road bridges are being constructed concurrently with this, they naturally cannot be completed until the whole of the lines are raised. The most northerly section of the new works is illustrated in Fig. 24, page 70. As will be noted, the tracks on the right have already been raised to the new level.

The line from Laeken to the Leopold Quarter was originally carried on an embankment, the lines from the North Station, which crossed it, passing through an interruption in the bank, and the line above passing over a bridge. In the year 1933, however, owing to the necessity of increasing the size of the marshalling yard, the embankment was replaced by a viaduct carried on piers. To allow of the lines to the North Station being raised to their new level, it has been necessary to arrange that the cross lines shall pass below the main lines instead of above them. The raised line is carried on a hollow concrete structure which is illustrated in Fig. 25, page 70. The bridge for the cross line can be seen on the left and part of the now-abandoned viaduct on the extreme right. This part of the reconstruction work has included the removal of the locomotive repair sheds from a position south of the cross line to a site near Schaerbeek Station.

As already mentioned, the rebuilding of the North Station and its raising by 8 m. will be carried out in strips, in a similar manner to the South Station. The new station will be 300 m. north of the existing one and will have its main entrance in the Rue du Progrès, which will be widened in the vicinity of the building. A long terrace, 4 m. above street level, will be constructed on the front of the building for tramcars serving the station; below this there will be accommodation for arriving and departing motor cars and for parking. The main entrance hall, containing the booking offices, etc., will be on the level of the terrace. It will be connected to the platform by escalators and stairs. The new station building will contain administrative offices for the Belgian Railways.

FINANCE AND OPERATION.

The works involved in the construction of the junction railway and the raising of the two main stations extend over a total length of 10 km., from Vorst in the south to the Teichman bridge at Schaerbeek. Of this length, only 3·1 km. represents the actual junction railway. The whole project involves the removal and relaying of 100 km. of track and the moving of hundreds of signal posts to new positions. Two million cubic metres of earth, derived from the tunnel excavations and elsewhere, are required for the raising of the stations. The construction of the tunnel and viaduct and all accessory work outside the stations was arranged to be carried out by the Belgian State under a National Bureau. The Minister of Traffic was the president of this Bureau, which included representatives of the National Society of Belgian Railways, the Ministries of Finance and Public Works, and the Brussels Municipality. It had a large technical staff which was responsible for the drawing up of the plans and the supervision of the work. The rebuilding of the North and South Stations was arranged to be carried out by the National Society of Belgian Railways, which would control the junction railway on its completion. The State voted a credit of 400 million francs for the construction of the junction railway, and a further sum of 200 million francs is expected to accrue from the new site values created. The expenditure on the rebuilding of the two main stations is also covered by the State, except that the National Society of Belgian Railways was required to find a sum representing the cost which, in any case, would have been spent in the modernisation of these stations, and would have been necessary even had the junction railway not been constructed.

It is expected that when the junction railway is in full operation some 800 trains a day will pass through the tunnel, or an average of one train every 10·8 minutes for each track. Naturally, the day traffic will be denser than this and the night traffic more sparse. In general, main-line trains which now end their journey at either the North or South Station will, in the future, serve both. Trains, for instance, from the north, after stopping at the North Station, will travel to Brussels Central and end their journey at the South Station. The same will apply in the reverse direction. There will, however, also be many important through services, such as the Amsterdam-Paris or Ostend-Basle trains, which will be able to pass through Brussels without reversing. It is the intention that all six lines of the junction railway shall be equipped with overhead trolley lines from the first, although the majority of the trains, in the early years at least, will be drawn by steam locomotives. The only electric service at present in operation, which will use the junction railway, is that connecting Brussels with Antwerp. It is intended, in due course however, that long-distance steam trains shall be hauled through the tunnel by electric locomotives which, if necessary, will be attached in front of the steam locomotive.

In connection with this project for the electrification of the junction railway, it may be said that there is a project for the electrification of the majority, or all, of the lines within a radius of some 25 km. around Brussels. A circle of about this radius embraces Mechlin on the Antwerp line, as indicated in Fig. 7, page 14, *ante*; Louvain, on the Liége line; Ottignies, on the Namur line; Nivelles, on the Charleroi line; Soignes, on the Paris line; Edingen, on the Lille line; Alost, on the Ghent line; and Termonde, on a secondary line which is shown in Fig. 7. These towns furnish the major part of the 150,000 passengers and 35,000 season-ticket holders who travel to Brussels daily. If a circle of 50 km. radius is drawn round the city it will include such towns as Antwerp, Namur, Charleroi, Mons and Ghent. The railways within this area have an aggregate length of 500 km. and handle about three-quarters of the total Belgian railway traffic. They serve a population of approximately six millions out of a total Belgian population of 8·3 millions. The provision of an adequate railway service connecting the various parts of this compact area has been greatly hampered by the lack of proper railway connection across Brussels, and the completion of the junction railway will enable the whole area to be dealt with in a more unified way. The conditions present a semi-suburban traffic problem and there is considerable possibility that, following the completion of the junction railway in 1942, the electrification at least of the area inside the 25-km. circle may be taken in hand.

In conclusion, we must express our thanks to Mr. A. Jacops, of the Société Nationale des Chemins de Fer Belges, to whom we are largely indebted for the information contained in this article. Considerable assistance has been furnished by his article published in the Journal of the Flemish Engineers' Institute. M. Jacops, in his turn, expresses thanks for assistance provided by Mr. E. Franchimont, Chief Engineer of the National Bureau for the Completion of the North-South Junction Railway. The figures accompanying the article were furnished by this Bureau, excepting Figs. 7, 9, 10 and 11, which are based on illustrations appearing in the *Annales de l'Institut Technique du Bâtiment et des Travaux Publics*, of Paris, in connection with the report of a lecture delivered by Professor Magnet, of the University of Ghent.

ROYAL AERONAUTICAL SOCIETY.—The Major Baden-Powell Memorial Prize for the best student in the associate-fellowship examinations of the Royal Aeronautical Society, held in May, has been awarded to Mr. H. D. Conway.

RECENT COURT CASES.—VII.

By W. SUMMERFIELD, M.A., B.C.L., LL.B.

Safe Access for Workmen.—In *Weaver* v. *Tredegar Iron and Coal Company, Limited* (1940), the claimant, Weaver, claimed that he was entitled to compensation under the Workmen's Compensation Act in circumstances which arise in a variety of forms of employment, including those in connection with a temporary site of work as well as those arising from operations at a permanent site; among such "temporary sites" are included, notably those where engineering construction is being undertaken. The claimant in this case failed before the County Court Judge and, again, before the Court of Appeal, but the House of Lords has now, by a majority of five to one, decided in his favour.

The respondent company operated a mine where the claimant was employed by them. The mine was near a road which some of the workmen used for walking or cycling from and to their homes, but it also abutted on a branch line of the London Midland and Scottish Railway, running between Tredegar and Newport. There was no regular station near the mine, but, as most of the workmen preferred to travel to and from their work by rail, the respondents had entered into an arrangement with the railway company, whereby the latter constructed platforms on each side of the line near the mine and ran a train in each direction at the time when shifts were changed. The trains were paid for by the respondent company, who deducted one penny per day from the workman's wages for the ticket supplied to him; nobody but an employee of the respondent company was allowed to use the platforms. On the day of the accident, in respect of which he claimed, Weaver had gone on to the platform in order to board a train to go home. The platform was crowded, and in the crush he was pushed on to the line and his arm was caught between two coaches of an incoming train. The injury involved the loss of his arm, and it was in respect of that loss that he put forward his claim.

The House of Lords decided in his favour on the ground that Weaver was using facilities provided by his employers for leaving the site of his work; he was upon premises which he was licensed to use; the licence to use had been obtained for him by his employers for the purpose of his employment; and he had no licence to use the premises where the accident occurred except as one of the conditions of employment. The House had thus approved a proposition enunciated in *Northumbrian Shipping Company, Limited* v. *McCullum* (1932), namely, that "the sphere of a workman's employment is not necessarily limited to the actual place where he does his work; if in going to or coming from his work he has to use an access which is part of his employer's premises, or which he is only entitled to traverse because he is going to or coming from his work, he is held to be on his master's business while he is using that access."

Engineering contractors frequently find it necessary or convenient to provide an access, either for their own employees or for others working at the premises where the contract is being executed; and, accordingly, it is of importance to them as well as to their clients (or the party for whom they are executing the works) to appreciate the extent of the protection thus afforded under the Act to workmen, even when such workmen are not at their actual place of work.

In the case of *McCullum* it was held that the accident arose "out of and in the course of his employment" in the following circumstances:—McCullum signed on as boatswain for a voyage and joined the ship when it was lying in Swansea Harbour. The terms of service embodied in his contract included a provision whereby he might be required to do duty as night watchman at overtime rates, and he was on such duty at the date of the accident. He was returning to the ship from his home, and on his way called at a public house which was situated just outside the entrance to the dock premises, which were private property. After leaving the public house he was never seen alive again, but later his body was discovered in the water about a thousand yards away from the ship. The finding of the Court, therefore, involved the propositions that McCullum was employed as a seaman at the time of the accident, notwithstanding that he was then on special duty as watchman; that the accident occurred on private premises (where the ship was lying), and that the risk which matured, namely, the loss of his life, was one of the risks incidental to his employment and which he would not have encountered if he had not been so employed. A useful test in such a case is: Was the effective risk one which the workman shared with members of the public, or was it one to which members of the public were not exposed—as being one incidental to employment as a seaman?

In *Newton* v. *Guest, Keen and Nettlefolds, Limited* (1926), when the case was before the House of Lords, the Lord Chancellor (Lord Cave) said that, where a "broad principle" had been decided by the House of Lords (the supreme judicial tribunal) it was highly undesirable that it should be "frittered away by fine distinctions." He delivered a similar dictum in the following year, in the case of *Jones* v. *South-West Lancashire Coal Owners' Association*. It is not always easy, however, to deduce a broad principle so as to be able to apply it with confidence to a particular set of facts arising from a particular contract or a special type of works, or to determine whether an employer is or is not seeking to draw fine distinctions to show that his employee is not entitled to claim under the Act. Thus, in the case of *Weaver*, both the County Court Judge and the Court of Appeal had held in favour of the employers on the ground that the accident was within the principle laid down in *St. Helen's Colliery Company* v. *Hewitson* (1924); and as indicated above, even in the House of Lords a dissenting view was expressed in favour of the employers in the case of *Weaver*. It is important and useful, therefore, to examine the *Hewitson* case, to see the distinction drawn between it and that of *Weaver*.

In *St. Helen's Colliery Company* v. *Hewitson* the facts were as follows:—Hewitson was employed as a coal hewer at the Siddick Colliery, some six miles from his home at Maryport; an ordinary weekly workman's ticket from Siddick to Maryport cost 3*s.* 9*d.*, but Hewitson travelled on a ticket for which he was charged by his employers 1*s.* 8*d.* per week, this sum being deducted from his wages. To obtain that ticket, he signed a form which included an agreement not to make any claim against the railway company for damage or accidental injury sustained while travelling by specified trains. These specified trains were provided for the colliery employees by the London and North Western Railway Company under a special arrangement whereby the colliery company agreed to indemnify the railway company against any claims by their workmen using the trains. On the day of the accident, Hewitson was returning from work on one of the trains when the engine fouled the points and was derailed, overturning the carriage in which he was travelling; he was, in consequence, injured. The County Court Judge found that there was in Hewitson's contract of service an implied term that he should be "entitled, if not obliged," to travel by the trains provided by his employers; further, that his employment began when he entered the train to go to work and ended when he left it on his homeward journey, although he was not paid for the time spent in travelling. The Judge therefore made an award in the employee's favour, which the Court of Appeal affirmed; but the House of Lords reversed those judgments and held in favour of the employers, one of the five Law Lords dissenting.

In the view of Lord Buckmaster, this accident did not occur to the workman "in the course of his employment" merely because he was on a journey by virtue of a right granted to him by his contract of service, any more than if he had been going on a holiday to which he was entitled by his contract of service and for which he was provided with a free ticket. He had a right to travel by that train, but was under no duty to do so; it was open to him, if he wished, to travel to and from his work by other means. Lord Atkinson thought that a good test of "in the course of his employment" was to ascertain whether what the workman was doing was something "in discharge of a duty to his employer, directly or indirectly imposed upon him by his contract of service"; but the term "employment," he added, "covers and includes things belonging to or arising out of it." Thus, he instanced, "haymakers in a meadow on a very hot day are doing a thing in the course of their employment if they go for a short time to get some cool water to drink to enable them to continue the work they are bound to do, and without which they could not do that work"; again, workmen are doing something in the course of their employment "when they cease working for the moment and sit down on their employer's premises to eat food to enable them to continue their labours."

It should be pointed out that in this case the trains were not exclusively reserved for employees of the colliery company, although they guaranteed a certain number and, in fact, about 90 per cent. of the passengers, as a rule, were employees of the colliery company.

Lord Shaw, in his dissenting judgment, agreed with the view of Lord Justice Farwell in *Gane* v. *Norton Hill Colliery Company* (1909), who had there said: "Employment is not confined to the actual working whether in a pit or at any other trade in which the workmen may be engaged. He is employed not only to work in the pit, but also to do other things that he is entitled to do by virtue of his contract of employment; for example, he is entitled to do, and therefore employed to do, such acts as coming on the employer's premises, passing and repassing for all legitimate purposes connected with his work on the premises, such as getting to the pit's mouth, going to get his wages, going to make proper inquiries from proper officers, or taking a train which he is entitled to use by virtue of his contract of service. All those things that he is entitled to do by virtue of his contract he is for the purposes of the Act employed to do, and they are therefore within his contract of employment." He added this qualification that the workman "must make a reasonable use of the facilities and rights which are given to him in this way." If, he proceeded, it was right to exclude from the scope of the terms of employment those things and dangers which merely spring from the exercise of rights within a contract of employment, then it was difficult to see where such a doctrine was to stop. For example, a man "goes for his wages from the yard to the office by a bridge provided by the employers and the bridge is broken or blown down and he is injured"; under such a doctrine it would be said that the workmen had no claim, because to go for his wages, "he might have chosen to walk round half a mile—to use the bridge was only his right—or, indeed, he might have chosen to go without his wages at all; he was not obliged to lift his money—to do so was only his right."

The House of Lords held in favour of the workman also in *John Stewart and Son* (1912), *Ltd.* v. *Longhurst* (1917). Longhurst was a carpenter, employed in repairing a barge lying in dock; after finishing his day's work, on a dark night, he started to walk along the quay to the dock gates, but fell from the quay and was drowned. The dock was private property to which members of the public did not have access. Longhurst had access by reason of the fact that his employers and their workmen had permission to pass through the dock to and from the barge. The decision was based upon the fact that the workman was on the dock premises solely by virtue of his contract of service and that, therefore, the accident arose "out of and in the course of the employment."

THE PROFESSIONAL CLASSES AID COUNCIL.—The annual report, for 1939-40, of the Professional Classes Aid Council shows a total income for the year of 15,026*l.*, of which 11,502*l.* was expended on relief. Administration expenses amounted to 1,426*l.*, and the excess of income over total expenditure was 693*l.* Investments, including those belonging to special funds, were valued at 38,062*l.* Financial aid and help in kind were given to 332 families. In addition, 391 were advised of suitable sources to approach for help, as were many of the 232 cases, whose applications were outside the Council's scope. The secretary of the Council is Miss G. M. Walters, 251, Brompton-road, London, S.W.3.

LETTERS TO THE EDITOR.

SPECIFIC SPEED OF PUMPS AND TURBINES.

TO THE EDITOR OF ENGINEERING.

SIR,—The conception of specific speed has proved of considerable value in the design of rotary hydraulic machines, and the practice of stating its value with published information on a machine has been growing of recent years. To an expert interested in this particular field, a knowledge of the specific speed provides a good deal of useful information. The type, shape, detailed losses, and overall efficiency may all be correlated approximately with specific speed. For instance, it is known that Kaplan, Francis and Pelton turbines all have their own particular range, and that their efficiency falls off towards either extreme of the range. Similar remarks apply equally well to propeller, mixed-flow, volute and turbine pumps.

Unfortunately, however, there are a number of different systems of units used in the calculation of specific speed, and the value obtained is different in each. This makes for a certain amount of confusion, and when dealing with data on foreign machines it necessitates a recalculation before familiar units can be obtained or a comparison be made with known values. At least six systems are used, two for turbines and four for pumps. Crossed conversion factors for all these six would take up a considerable amount of space, but, I would suggest, the whole question of conversion may be simplified by the use of a "master" specific speed value of non-dimensional form. A set of six factors for each of the six systems can be given, and perhaps it may not be too much to hope that, when this non-dimensional system becomes better known, both the "local" and "master" values could be given. Finally, the "local" value might eventually disappear, leaving one universal system.

The usual expressions for specific speed are

$$N_s = \frac{N\,P^{\frac{1}{2}}}{H^{\frac{5}{4}}} \text{ for turbines,}$$

and

$$N_s = \frac{N\,Q^{\frac{1}{2}}}{H^{\frac{3}{4}}} \text{ for pumps,}$$

where N_s = specific speed, N = rotational speed in revolutions per minute, H = head in ft. or m., P = h.p. (English or metric), and Q = flow rate in cub. ft. per second, British or U.S. gallons per minute, or litres per second.

If the physical dimensions of specific speed be examined, they will, at first sight, appear extraordinary, since they involve fractional powers of mass, length and time. This is accounted for, however, by the suppression of dimensional quantities, which may normally be presumed constant. Strictly speaking, specific speed, being representative of type and independent of size, should be non-dimensional. A non-dimensional form is

$$n_s = \frac{n\,p^{\frac{1}{2}}}{\rho^{\frac{1}{2}}\,(g\,h)^{\frac{5}{4}}} \text{ for turbines,}$$

and

$$n_s = \frac{n\,q^{\frac{1}{2}}}{(g\,h)^{\frac{3}{4}}} \text{ for pumps}$$

The letters n, p, q and h represent self-consistent values, corresponding to the locally convenient values of N, P, Q and H, respectively. ρ and g represent density and gravitational acceleration, and are the quantities

—	Specific Speed N_s in Terms of			Conversion Factor to Non-Dimensional Form n_s. Divide by
	N.	Q.	H.	
Pumps	R.p.m. ..	Imperial galls. per min.	Ft. ..	15,700
	,, ..	U.S. galls. per min.	,, ..	17,200
	,, ..	Cub. ft. per sec.	,, ..	811
	,, ..	Litres per sec.	Metres ..	10,500
	N.	P.	H.	
Turbines	R.p.m. ..	British h.p.	Ft. ..	273·2
	,, ..	Metric h.p.	Metres ..	1,213

suppressed in the usual values. In order to make perfectly clear what units may be used, it may be advisable to give them in one case. Assume the "slug," foot, and second as the units of mass, length and time, respectively, then the units of n are revolutions per second, of p are ft.-lb. per second, of ρ are slugs per cubic foot, of g are ft. per sec. per sec., of h are ft., and of q are cub. ft. per second.

Although two values of n_s have been given in the accompanying table, one for pumps and the other for turbines, these are, for most practical purposes, the same value for similar machines. This may be easily deduced by writing for the turbine

$$g\,h\,\rho\,q = \eta_t\,p,$$

where η_t is the turbine efficiency. Substituting for p, we have

$$\sqrt{\eta_t}\,n_s\,(\text{turbine}) = n_s\,(\text{pump}).$$

It will be seen, therefore, that the specific speed of a pump corresponds numerically to that of a similar turbine with 100 per cent. efficiency. Since small variations in specific speed are of very little practical importance, the term $\sqrt{\eta_t}$ may often be ignored.

Any reference to the specific speed of fans and blowers has not previously been noticed, but it is obvious that the same non-dimensional value would apply. The head quantity h is not used in connection with fans, but the quantity $g\,h$ may be replaced by its exact equivalent $\frac{p'}{\rho}$, where p' is the increase of dynamic pressure. In order to determine the non-dimensional value it will generally be simpler to calculate the "locally convenient" value, and then to use the factor in the table for conversion, than to convert each unit to its consistent form first.

Yours faithfully,
J. JENNINGS, B.Sc., A.M.I.Mech.E.

Aston Technical College,
Birmingham, 6.
July 10, 1940.

WORKING HOURS AND REST PERIODS.

TO THE EDITOR OF ENGINEERING.

SIR,—In an article on "Working Hours and Rest Periods" in your issue of July 5, and in another article on May 17, you criticise the Industrial Health Research Board for not producing adequate evidence in support of their belief that a reduction in excessive hours of work increases output. As you point out, they illustrate this proposition by a single example; but this was merely illustrative, and a number of other detailed examples are recorded in the Memoranda (Nos. 12 and 18) of the Health of Munition Workers Committee, and in Report No. 6 of the Industrial Fatigue Research Board. As the investigator responsible for collecting and analysing the data in question, will you allow me to recapitulate briefly some of the voluminous evidence obtained?

In the first place, it must be admitted that, in your criticism of the example given by the Board, you have been misled by a footnote in Emergency Report No. 1, which incorrectly defined the meaning of "Nominal Hours of Work." These hours did not, as the footnote stated, represent the time spent in the factory, but only the hours fixed by the management for attendance, while the "Actual Hours of Work" were those for which the men were present in the factory. These men were never, in my experience—and I was constantly in and out of the factory in 1916 and 1917—kept waiting for material. The factory was, in fact, one of the best-equipped and best-run organisations in the country, where the 10,000 workers employed produced over 300,000 time-fuses a week, as well as other munitions.

The hourly output figures quoted by you relate to the actual hours of work, and they show that, when the men were on a 56½-hour week (*i.e.*, a regular 10-hour day, without Sunday labour) their total production was 22 per cent. greater than when they were on a 66¾-hour week, and were working on some days for 12 hours and on others for 10 hours, together with intermittent Sunday labour. Exact information about the hours worked each week and the output is recorded over a continuous period of 22 months in the above-mentioned Memoranda and Report.

The men were able to improve their rate of production so remarkably because they were engaged on a hand-work job (sizing fuse bodies) in which they were not limited in any way by machinery. The other groups of workers studied were all limited by machinery to some extent, but nevertheless an analysis (over a two-year period) of the output of a group of 100 to 80 women employed in turning fuse bodies on capstan lathes showed that, when they were on a 10-hour day, without Sunday labour, their total production was 13 per cent. greater than when they were on either a 12-hour day or a 10-hour day in which Sunday labour was also imposed.

Another group of women, who were milling a screw thread on the fuse bodies, were more restricted by the machine, but nevertheless they attained practically the same total output when they were on a 57-hour week (without Sunday labour) as on a 72-hour week with it. The Health of Munition Workers Committee were emphatic in condemning Sunday labour, and they stated that "the discontinuance of Sunday labour should be of universal application and should extend to all classes of workers, except that where the work must necessarily be continuous special arrangements will be necessary." You, yourselves, in your article of May 17, deprecate a general Sunday holiday, but the evidence here adduced, and much other evidence collected by the Health of Munition Workers Committee, is strongly in favour of it, or rather in favour of one free day per week. The machinery need not be left idle on this day, for it can be kept running by a relay system of workers. Indeed, Mr. Bevin recently stated that he hopes to organise a scheme under which women would work in accordance with the Factory Acts (*i.e.*, for 48 hours to 54 hours a week).

Yours faithfully,
H. M. VERNON.

94, Prince of Wales' Mansions,
Battersea Park, S.W.11.
July 16, 1940.

[We are glad to publish Dr. Vernon's letter: it does much to elucidate the information given in the Industrial Health Research Board's report. As that report stated that "'Actual' means the nominal hours of work *minus* time lost for various reasons, such as waiting for work," no apology is required from us for our elementary arithmetic, which showed that the men stood about for a time equal to 24 per cent. of the hours they were actually working. The fact that, on Dr. Vernon's showing, this statement was incorrect adds weight to our criticism of this part of the report. —ED., E.]

THE FRENCH ALUMINIUM INDUSTRY.

IN view of recent happenings in Europe, it is of some importance to recall that, for many years past, France has been a great aluminium-producing country, this being due to the circumstances that she possesses enormous deposits of good quality bauxite and ample water power for the production of metallic aluminium. Although the ore takes its name from the town of Baux, near Arles, it is now chiefly obtained in the Var Department, which supplies some 80 per cent. of the total French output. Other deposits exist in the Hérault Department, and in the regions adjoining the estuary of the Rhone. During 1937, the production of bauxite in French mines and quarries, namely, 688,200 tons, constituted a high record figure, equivalent to one-fifth of the total world output for that year. Of this quantity, 300,000 tons were exported for treatment overseas, much of the total being consigned to the United Kingdom, as British aluminium producers own large deposits in France. Works in France, however, produced 34,500 tons of aluminium metal in 1937 and 43,000 tons in 1938. This latter figure represented approximately the maximum productive capacity of the French industry at that time, but plans for expansion were subsequently brought forward, although it is doubtful whether many of the extensions envisaged could have been completed before hostilities commenced.

The chief aluminium-producing districts are centred round Marseilles and in the Basses-Alpes and Pyrenees regions. Moreover, France held considerable interests in hydro-electric reduction plants in Norway, which relied upon imported bauxite. It would appear that, by her occupation of France, one of Germany's chief gains is that she has secured access to supplies of good quality ore, a commodity which she has always lacked. In this connection, however, it should be remembered that recent German plant extensions have been developed with particular regard to the exploitation of ores of low quality, and may not be able immediately to take the fullest advantage of a better product. It is probable, of course, that Germany will make use of French plants even in "unoccupied" areas.

A FAMOUS RECORD-BREAKING CAR.—The 1,000-h.p. Sunbeam motor car, in which the late Sir Henry Segrave set up a world's record of 203·7 miles per hour at Daytona Beach in March, 1927, has been carefully preserved by Messrs. Sunbeam Commercial Vehicles, Limited, Moorfield Works, Wolverhampton, who were the builders of the car. It has recently been lent by the firm to Loughborough College, at the request of Dr. Herbert Schofield, M.B.E., the Principal, and has been placed on view with other unique "museum pieces" for the benefit of the students of the College.

LABOUR NOTES.

THE Order of the Minister of Labour and National Service providing for compulsory arbitration in industrial disputes during the war, and prohibiting strikes and lock-outs, came into force yesterday. Mr. Justice Simonds has been appointed chairman of the National Arbitration Tribunal, of which other members are Sir John Forster and Sir Hector Hetherington. There are, in addition, two representatives chosen from panels approved by the British Employers' Confederation and the General Council of the Trades Union Congress.

Under the Order, any dispute, existing or apprehended, may be reported to the Minister by either party to it, and the Minister will refer it for settlement by any suitable machinery in the industry. If there is failure to reach a settlement, or if a settlement is unduly delayed, the Minister may refer the matter to the National Arbitration Tribunal for an award. Where there is no suitable conciliation machinery the Minister will take other steps to promote a voluntary settlement, and again failing a settlement, the matter will go to the National Tribunal. Any settlement of a reported dispute, whether by agreement, decision or award, will be binding on the employers and workers concerned.

The Order also lays it down that all employers must observe terms and conditions of employment not less favourable than the "recognised terms and conditions" which have been settled, through machinery of negotiation or arbitration, by organisations of employers and trade unions representatives respectively "of substantial proportions of the employers and workers engaged in that trade or industry in that district." Other provisions in the Order relate to the recording of departures from trade union practices during the emergency. If the employers and the workmen do not agree on a memorandum, there may be two separate records, but in that case an officer of the Ministry will prepare an independent memorandum. The Order does not cover the restoration of the surrendered trade union practices for which a guarantee is to be given by other means.

At a Rules Revision Conference of the Electrical Trades Union at Morecambe last week, it was decided to amend the rules to permit of the enrolment, as members, of technical administrative and supervisory workers in the electrical industry. Mr. Rowan, the general secretary of the organisation, explained that the step had been rendered necessary by legislation affecting the industry and by big changes, particularly in electrical supply and distribution. It would considerably increase the membership of the union, he added.

From August 1 onward, the Factory Acts are to be put in full operation again. Speaking in London on Wednesday last week, Mr. Bevin, the Minister of Labour and National Service, said that the operation of the Acts had recently become somewhat demoralised. Appeals rising from great exuberance to put in extraordinarily long hours had resulted in many cases of young people working 70 hours or 80 hours a week. He felt it to be his duty to stop that, and for that reason, the Acts would be enforced at full strength again. All the evidence went to show that we had carried on with these long hours too long, and that production was declining rather than increasing. He hoped that employers would use the scale of times and rotas that the Ministry of Labour and National Service was now suggesting. That would, he believed, give maximum production without injuring the physical health of the workers.

Mr. Bevin is considering a scheme under which men and women with the right "psychological make-up" for welfare work may obtain a period of training at universities and return to the factories. They would be given scholarships tenable at Liverpool University or Birmingham University, where courses in this kind of study have been instituted. He is convinced that men and women with the proper flair for the work can be of almost incalculable value in making the wheels of industry run smoothly and thereby increase production. There are, in his opinion, far too many accidents and he believes that welfare officers with a sympathetic insight into the difficulties of the workers will be able to decrease the number immensely.

The occupations which have been certified by the Ministry of Labour and National Service as "employment for war purposes" coming within the scope of the Superannuation Schemes (War Service) Act, 1940, are set out in a leaflet issued last week. The act permits an employee to continue contributions to a superannuation scheme after he has left the employment to which the scheme relates in order to take up war service. "Employment for war purposes" has been defined as any employment in (*a*) General engineering, that is to say, the manufacture, assembly or repair of goods or articles of iron, steel or non-ferrous metals which involves the use of machine tools, foundry or forging plant but does not include the construction of the hull of any ship or any ship repair work. (*b*) Shipbuilding, that is to say, the construction of the hulls of ships and ship repair work. (*c*) Agriculture, including forestry and horticulture. (*d*) Any training for any of those employments. Further employments may be certified.

At its annual conference—which took place at Blackpool last week—the Mineworkers' Federation of Great Britain adopted a resolution instructing the executive to negotiate a demand for a weekly minimum wage for all adult workers in or about coal-mines of 3*l.* a week.

The Ministry of Labour and National Service states that on July 1 the official cost-of-living figure was 87 points above the level of July, 1914, compared with 81 points at June 1. The rise of six points (*i.e.*, from 181 to 187—the figure for July, 1914, being 100) is equivalent to rather more than 3 per cent. For food alone the index of July 1 was 68 points above the level of July, 1914—showing a rise of 10 points, or over 6 per cent., since June 1, when the figure was 58 points above the level of July, 1914. The rise was mainly due to the substantial increase in the average price of potatoes, resulting from the partial displacement of old potatoes by the new crop at higher prices, and to increases in the price of milk. There were also increases in the average prices of eggs and fish.

The writer of the editorial notes in the July issue of *Man and Metal*, the journal of the Iron and Steel Trades Confederation, says:—"With the growing frequency of air raids, the work of our members in mills, melting shops and other plants is becoming more arduous and dangerous. Up to the time these notes are being written, the casualties amongst our people have been very slight, and we have not received a report of anyone fatally injured. This is probably due to the excellent system of precautions that exists in most works, although to our knowledge, in some places, there is still considerable room for improvement. Another feature is, no doubt, the disciplined behaviour of the men working on the plants. Now, they are reaping the advantage of the training they have had in this matter over the last several months."

It has already been announced in these columns that the Transport and General Workers' Union and the National Union of General and Municipal Workers have each lent the Government 250,000*l.* free of interest. It has also been mentioned that the General Council of the Trades Union Congress has lent 10,000*l.* on the same terms. Amongst other organisations which have decided to make interest-free loans are the Electrical Trades Union (50,000*l.*), Transport and General Workers' Union, Power Workers' Group (3,000*l.*), National Amalgamated Society of Operative House and Ship Painters and Decorators (25,000*l.*), Tailors and Garment Workers' Union (10,000*l.*), National Amalgamated Union of Shop Assistants, Warehousemen and Clerks (2,500*l.*), Lancashire and Cheshire Miners' Federation (21,000*l.*), Amalgamated Association of Card, Blowing and Ring Room Operatives (5,000*l.*), Amalgamated Society of Wire Drawers and Kindred Workers (100*l.*), General Federation of Trade Unions (10,000*l.*), National Association of Theatrical and Kine Employees (2,000*l.*), National Society of Operative Printers and Assistants (10,000*l.*), Blacksmiths, Forge and Smithy Workers' Society (3,000*l.*).

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—The Autumn Meeting of the American Society of Mechanical Engineers is to be held from September 3 to September 6, at Spokane, Washington, when papers will be read before the hydraulics, wood-industries, heat-transfer, fuels, power and management divisions of the society. Parties will visit the Grand Coulee Dam, a lumber mill, the mines of northern Idaho, the Columbia River basin, and the scenic lakes of the district. The visitors to the Grand Coulee Dam, it is stated, will be able to see the concrete work of this dam, described as "the world's largest masonry structure," in its final stages, and some part of the work of installing the hydraulic machinery. The headquarters for the meeting will be at the Hotel Davenport, Spokane.

PNEUMATIC BLOW GUN.

NUMEROUS accidents occur each year as the result of ill-advised attempts to clear away dust and swarf by hand from moving machinery or electrical apparatus, the use of both rags and brushes for this purpose being often highly dangerous. More careful persons occasionally employ hand-bellows, but these are not always conveniently manipulated. The pneumatic blow gun shown in the accompanying illustrations, Figs. 1 and 2, offers a safe and convenient alternative. It is made by Messrs. B.E.N. Patents, Limited, High Wycombe, Buckinghamshire, and, since it weighs under ½ lb., it is easily handled even in awkward situations. The blow-gun is intended for use in workshops where compressed air is available, and it is therefore provided below the hand grips with a ¼-in. hose connection. The body is of aluminium and the renewable nozzle is of bronze. The nozzle can have a bore of either $\frac{1}{16}$ in., $\frac{1}{8}$ in., or $\frac{3}{16}$ in., as desired, and, alternatively, for use where live electrical fittings are

Fig. 1.

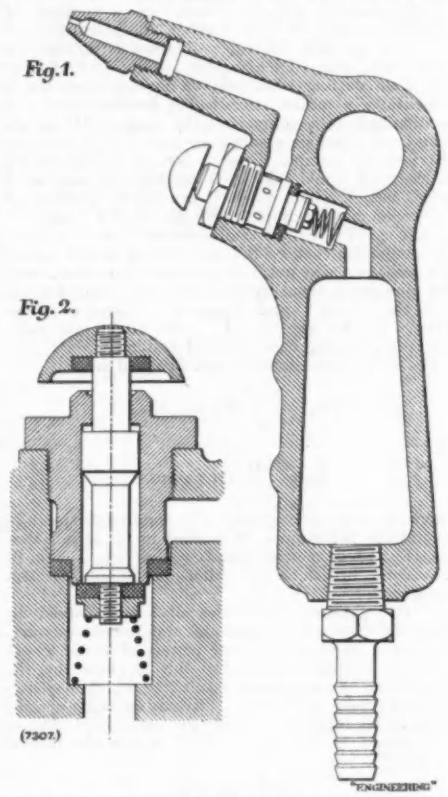


Fig. 2.

(7307)

"ENGINEERING"

concerned, can be made of insulating material so that safe operation is ensured should accidental contact be made. Control of the air jet is effected by the push-button illustrated in Fig. 2, and actuated by the forefinger of the hand holding the gun. The valve is readily renewable. The hole seen above the control button in Fig. 1 is for hanging the gun from a hook when not in use. We understand that the blow gun has proved of great service in blowing dust from foundry moulds and is particularly effective in getting rid of the dust formed in machining operations on non-metallic materials, such as plastics, this dust being difficult to displace by means of bushes or rags. Its application to woodworking machinery for the removal of sawdust and shavings is obvious.

To enable the gun to be readily connected to existing air supplies, Messrs. B.E.N. Patents have developed a neat pressure-reducing valve manufactured from bronze pressings and having a diaphragm of the oil-resisting rubber insertion type. The valve will reduce an initial pressure of 150 lb. per square inch to any pressure between 5 lb. and 100 lb. per square inch, the adjustment being made by a thumbscrew. The inlet and outlet openings are screwed ¼-in. gas and are socketed. A connection of the same size and type is provided for a pressure gauge. The valve has a nickel-plated finish and is stated to be unaffected by oil or water and not to vibrate or chatter in use.

THE UNITED STATES MOTOR-CAR INDUSTRY.—The production of motor cars in the United States is undergoing a seasonal decline. The output for the first week in July was 51,975 cars, compared with 87,550 cars in the preceding week. It is expected that most firms will slow-down, or temporarily cease, manufacture towards the end of July pending the introduction of new models.

COAL CHARACTERISTICS AND PULVERISED-COAL FIRING.*

By OLLISON CRAIG.

WHEN coal is burned in pulverised form in a furnace, that portion of overall boiler efficiency for which combustion is responsible is high when carbon loss is kept at a minimum, when the CO_2 or excess air is maintained within predetermined limits, and when combustion as defined by this carbon loss and this excess air is completed, within the limits of the furnace volume. Continuous and trouble-free operation is secured if ignition is maintained constant and steady, and if molten ash in the form of slag does not accumulate in any portion of the furnace or on boiler heating surfaces to such an extent as to interfere with efficient operation. Carbon loss, excess air, and slag are affected by the characteristics of coal being burned, the design of the furnace, the design of the burners, and the characteristics of the pulverisers. The characteristics of coal which affect the burning of coal in pulverised form, and affect the results which are obtained from pulverised-coal firing, are: volatile matter, fixed carbon, agglutination, swelling, ash, ash-fusion temperature, moisture, sulphur, and grindability.

Bituminous coals, in general, vary from 15 per cent. to 40 per cent. in volatile matter. Coals containing less than 22 per cent. are classed as low-volatile; coals containing from 22 per cent. to 31 per cent. are classed as medium-volatile; coals containing more than 31 per cent. are classed as high-volatile. When high-volatile coal is burned in pulverised form, volatile gas is first distilled and burned, leaving fixed carbon for final combustion. Such coal will burn out more quickly and more completely than would be the case with low-volatile coal, provided all other conditions are the same. If a high-volatile coal, containing 30 per cent. volatile on a moisture- and ash-free basis, is burned, then, for each lb. of combustible matter introduced into the furnace, there is 0·3 lb. of volatile gas produced and 0·7 lb. of fixed carbon remaining. If a coal, containing 20 per cent. volatile matter on a moisture- and ash-free basis, is burned, there is 0·2 lb. of volatile gas released for each lb. of combustible and 0·8 lb. of fixed carbon remaining. Since volatile gas distils and oxidises quite rapidly, the length of time to complete combustion, to the point where there is a predetermined amount of unconsumed carbon remaining in the ash, is less in the case of high-volatile than low-volatile coal, since there is a less amount of the slow-burning fixed carbon. The effect of a greater amount of volatile matter in coal on the determination of furnace volume (or conversely, heat release per cubic foot) is to require a smaller furnace volume, provided the size of the furnace is not dictated by other considerations. If furnace volume is established, then the loss due to unburned carbon in ash will be less with high-volatile than with low-volatile coal, assuming the coal to be ground to the same fineness and that all other conditions are constant.

Quick ignition and stability of ignition are of much importance in pulverised-coal firing, and are dependent on velocity of flame propagation in a mixture of pulverised coal and air, on the temperature at which heat may be radiated to the incoming mixture, and on the temperature in the region through which the mixture passes before leaving the furnace. Pulverised, high-volatile coal, when mixed in suspension with air and ignited, has a higher velocity of flame propagation than low-volatile pulverised coal. High-volatile pulverised coal which is low in ash, and which is mixed with the proper amount of air, may have a flame-propagation velocity as high as 2,800 ft. per minute. With low-volatile pulverised coal, this velocity may be less than 1,000 ft. per minute. If the velocity of flame propagation of a coal and air mixture being introduced into a furnace is low, then the velocity of discharge of this mixture and the velocity of the secondary air which may be admitted at the burner must also be low, to permit ignition and to prevent extinguishing the flame. A wider range of operation can be had with mixtures having higher velocities of flame propagation, since ignition can be maintained over a wider range of velocities of discharge from the burner. Quicker ignition and better flame stability are obtained with high-volatile coal for another reason. A mixture of coal and air must be heated to the temperature at which the coal will ignite. This requires a source which can supply heat to the incoming coal and air. More volatile gases are distilled from high-volatile coal, and produce a zone of higher temperature in the region near the burner, from which heat can be radiated to the incoming fuel and air.

If pulverised coal is burned at a given rate in an all-refractory furnace, the loss due to unburned carbon is less than it would be if the same coal were burned at the same rate in either a partially or completely water-cooled furnace. This fact would indicate that water-cooled surfaces in a furnace tend to retard combustion of fixed carbon. It might be considered that this could be compensated for by burning coal at a greater rate, thereby raising the average furnace temperature. However, this does not accomplish the purpose, since with an increased rate of coal burning, a particle of coal is in the furnace for a shorter time, and the fixed carbon is less completely burned. Other means can be taken partially to compensate for the cooling effect of water-cooled furnaces. Coal and air can be introduced by means of multiple burners in such a way as to produce more turbulence; the scavenging action will then result in more complete combustion of fixed carbon and will, thereby, at least partially compensate for the slower burning produced by lower furnace temperature. Here again, high-volatile coal has an advantage, since it is not so greatly affected by the cooling action of water-cooled furnaces as is low-volatile coal; if a high-volatile coal is burned in a water-cooled furnace at a given rate, the loss due to unburned carbon is less than when burning low-volatile coal in the same furnace at the same rate.

The difference is so pronounced that it frequently becomes necessary to make corrective modifications in the case of water-cooled furnaces when low-volatile coal is burned. One method is to reduce the rate at which heat is absorbed by water-cooling surfaces in the furnace. This may be done in the original design by the application of heat-retarding blocks or refractory material to the surface of furnace water tubes, or it may be done later, after experience with operation has indicated the necessity, by the application of refractory material over the surface of the water tubes, on those areas of the furnace walls on which it may be the most effective. These areas are usually in line with the burners on the side walls, and in some cases on the rear wall, and extend a few feet above and below the centre line of the burners.

The effect of such heat-retarding material is most strikingly illustrated in the case of burning petroleum coke, which usually has less volatile matter than even low-volatile coal. The volatile matter of petroleum coke may be from 7½ per cent. to 20 per cent., and is usually below 15 per cent. It is almost impossible to ignite and maintain a stable flame with this material in an entirely water-cooled furnace. Recently, an oil refinery started burning pulverised petroleum coke in furnaces of existing boilers, originally built for oil firing and later modified for firing pulverised coal by the application of waterwalls to the side and rear walls. When pulverised petroleum coke was first burned in these furnaces, the fly-ash leaving the boilers was excessive, and its carbon content was quite high. A 10-ft. belt of refractory was placed on each side wall, the centre of this belt being in line with the centre line of the horizontal burners. Later, a 10-ft. belt was placed on the rear wall. Half the waterwall area in each furnace was then covered with refractory extending 2½ in. beyond the surface of the tubes. Before refractory was applied, fly-ash loading in the stack gases at about 400 deg. F. was from 3 grains to 6 grains per cub. ft., and its carbon content was from 96 per cent. to 97 per cent. With refractory on the side walls, fly-ash loading in the gases was reduced to 1·25 grains to 1·5 grains per cub. ft., and the carbon content to a range of 88 per cent. to 92 per cent. With refractory on three walls, the fly-ash loading dropped to 0·3 grain per cub. ft. and the carbon content to 70 per cent. to 75 per cent. The carbon content in the fly-ash is apparently high, but the original coke contained only 0·7 per cent. ash. This experience illustrates, in possibly an exaggerated form, the necessity for compensating for the low-volatile content of pulverised coal.

Practical considerations dictate the necessity of constructing pulverised-coal furnaces with walls composed almost completely of water tubes. With such furnaces, high-volatile coal has an advantage in initial ignition, stability of flame, and carbon loss. This usually requires in such furnaces, where low-volatile coals are to be burned, the application of heat-retarding material to the water-cooled surfaces. In some cases, this can be sufficiently accomplished by the accumulation of ash on the surfaces of furnace-wall tubes. In other cases, it becomes necessary to apply refractory or some form of blocks.

Certain kinds of coals have a tendency to caking or "agglutination." When such coals are burned on grates or on a stoker, the effect is to produce a fuel-bed condition in which coal particles and lumps adhere to each other in such a way as to be largely impervious to the passage of air. Some form of agitation is necessary to break up these cakes of fuel in order that air can have access to the surfaces of coal particles. Similar adherence of particles occurs when this kind of coal is fired in pulverised form. A large number of separate and individual particles, which have been reduced to an extremely fine state in a pulveriser, can, when subjected to heat in the furnace, collect and adhere together so as to form an individual mass. The result is the same as if coal were introduced which had been quite coarsely ground. The effect of agglutination, when coal is pulverised, is to increase the loss due to unconsumed carbon, because these accumulated masses cannot become as completely burned in the time of passage through the furnace as can the smaller individual particles. Certain bituminous coals swell or increase in volume when subjected to heat. If such a coal is pulverised and introduced into a hot furnace, each coal particle swells. Since each particle increases in volume with no increase in weight, it is carried more rapidly by the gas stream and is in the furnace a shorter time. The result is increased carbon loss.

The amount of ash in coal will vary from 5 per cent. in some low-volatile coals to 20 per cent. in some low-grade coals. The effect of a greater amount of ash in pulverised coal is to reduce flame velocity in a mixture of coal and air and, as a result, to interfere with ignition and flame stability. The minimum rate at which high-ash coal can be burned in a furnace with continuous firing is greater than with a coal having a less amount of ash, but the same volatile. Experience seems to indicate that it is possible to operate with as low percentage of excess air with a high-ash coal as with low-ash coal, and also that, with this same percentage of excess air, the total loss due to unburned carbon is about the same. In order that the total loss due to unburned carbon should be about the same with the high-ash coal, it is necessary that the percentage of carbon in ash and refuse be less than in the case of low-ash coal.

Coal ash will fuse at temperatures ranging from 1,800 deg. F. to 2,800 deg. F. Softened or molten ash will adhere to furnace surfaces, furnace outlets, and heating surfaces of boiler and superheater. Fused ash which deposits in the furnace causes increased refractory maintenance and interferes with ash disposal, and on boiler and superheater surfaces it reduces heat absorption and closes gas passes. If sufficient water-tube surface is exposed to radiation from the furnace, fine ash particles may be reduced to less than fusion temperature before entering the tube bank. If, in addition, such refractory surfaces as may be in the furnace, and also the ash outlet from the furnace, are kept at a sufficient distance from the flame, no trouble will be experienced by slag accumulation on furnace walls or by slag blocking the ash outlet. Average furnace temperature can be reduced by burning coal with a greater amount of excess air, at the expense of boiler efficiency. This is frequently resorted to when coal must be burned having ash with lower fusion temperature than was contemplated when the furnace was designed.

The high moisture content of coal affects the performance of a pulveriser; it tends to reduce capacity and fineness of pulverisation, and increases the power required. The immediate effect of moisture in pulverised coal after it is introduced into a furnace is to interfere with ignition. If there is water in the coal particles, more heat must be received by a coal particle to bring it to ignition temperature. After the water has been evaporated, the vapour then probably acts as a diluent to the volatile gases and retards combustion in much the same way that ash does. However, it is possible that a certain amount of water in certain kinds of coal may so affect the process of combustion as actually to result in an increase in the efficiency of the steam-generating unit, through a reduction in unburned carbon or through an ability to operate with less excess air with the same unburned carbon. It is known that it is almost imperative to have more than a normal moisture content with certain caking coals, if these are to be successfully burned on a travelling-grate stoker. The action of moisture in coal which produces these results in the case of stoker firing may or may not be similar to the action which occurs in the case of pulverised-coal firing. It might seem, however, that, at least with certain kinds of coal, there could be some amount of moisture in coal particles which, in the process of evaporation and expansion, could leave the coke particle in such a condition that it would be more capable of combining with oxygen. The effect of unusual moisture content, however, is to interfere with ignition, and stability of flame, and to cause erratic combustion and increase in carbon loss. Usually it is not economical to dry coal which is to be pulverised in a direct-firing system. If the coal is dried, heat must be supplied for evaporating the moisture in any case. Unless this is supplied from waste heat leaving the boiler, the cost of the heat for drying may be greater than the loss in heat carried away in the vapour.

The sulphur content of coals varies through a wide range and may be as low as ½ per cent. and as high as 5 per cent. Sulphur in coal usually occurs in the form of iron pyrites. A large amount of sulphur is usually an indication that the ash-fusion temperature is low and that trouble will be experienced both from slag resulting from this low ash-fusion temperature and

* Paper presented at the Spring Meeting of the American Society of Mechanical Engineers, at Worcester, Massachusetts, U.S.A., May 1-3, 1940. Abridged.

from the effect of the iron which is combined with the sulphur in iron pyrites.

Grindability is a measure of the ease or difficulty with which coal can be reduced to a fine state. Any index is usually expressed in terms of a numerical value, and 100 on a chosen scale represents a certain grindability which is used as a measure of comparison. All types of pulverisers will have less capacity with coal of low than of high grindability. At the same rate of grinding in terms of pounds of coal per hour, and with the same power input, coal of low grindability will be pulverised to a less degree of fineness than will be the case with coal of high grindability. There is a broad relation between volatile matter of bituminous coal and grindability. Coal having from 15 per cent. to 25 per cent. of volatile will generally fall within the range of 90 to 100 grindability, while coal having 30 per cent. to 35 per cent. volatile will generally fall within the range of 50 to 65 grindability. It seems fortunate that low-volatile coal does have high grindability since, with the same pulverising equipment, it can be reduced to a finer size, and a finer size tends to compensate for the effect of lower percentage of fixed carbon. It is not necessary to pulverise high-volatile coal to the same degree of fineness as low-volatile coal, since there is less fixed carbon to be burned.

It might seem that all the advantages are with high-volatile coal in pulverised-coal firing. Such is not the case. Low-volatile coal is usually more friable. This results in a lower purchase price for equipment, less power to operate, and less expense for maintaining pulverising equipment. Low-volatile coals average higher in heat value, so that less weight of coal is required to generate a given amount of steam. The ash from low-volatile coal usually fuses at a higher temperature, so that less boiler and furnace maintenance is required and boilers may be kept in operation for longer periods of time.

CATALOGUES.

Lubricating Oils.—We have received from Messrs. E. G. Acheson, Limited, Thames House, Millbank, London, S.W.1, a leaflet describing the properties and method of application of their oil containing "dag" colloidal graphite.

Air Compressors and Equipment.—We have received from Messrs. B.E.N. Patents, Limited, Hughenden-avenue, High Wycombe, Buckinghamshire, a catalogue which gives details of B.E.N. air compressors, spray-painting equipment and tools.

Multicore Solders.—Since the outbreak of war, Messrs. Multicore Solders, Limited, Bush House, London, W.C.2, have developed cored solders which contain three independent cores of Ersin flux. A booklet received from this firm describes the result of their research work in this connection.

Pneumatic Tools.—Messrs. The Consolidated Pneumatic Tool Company, Limited, 232, Dawes-road, London, S.W.6, have sent us the latest edition of the catalogue covering their entire range of pneumatic tools. This catalogue is fully illustrated and contains notes on the care of pneumatic tools.

Air Extractors.—Messrs. Vent-Axia, Limited, 9, Victoria-street, London, S.W.1, have sent us a leaflet describing methods of fitting their air-extractors so as to comply with the black-out regulations. The extractors are light-proof and, being readily fitted in windows and rooflights, involve no structural alterations.

Turret-Lathe Performance Data.—Messrs. Gisholt Machine Company, 1215, East Washington-avenue, Madison, Wisconsin, U.S.A., have sent us performance data relating to the turret and automatic lathes of their manufacture. The actual tooling is illustrated, with the operation sequence and machining time included.

Optical Pyrometers.—Messrs. Elliott Brothers (London), Limited, Century Works, Lewisham, London, S.E.13, have sent us a pamphlet dealing with a disappearing-filament type of optical pyrometer, designed for measuring very high temperatures for which it is impracticable to employ thermo-electrical pyrometers. The temperature scale of this instrument is based upon Wien's law.

Machine Tools.—A folder received from Messrs. Soag Machine Tools, Limited, 7, Juxon-street, Lambeth, London, S.E.11, gives illustrated particulars of a 12-in. centre high-duty lathe, with twelve spindle speeds, and a radial drilling machine with 32 speeds, made by the American Tool Works Company. Larger sizes and ranges of both machines are also illustrated and described.

Acid-Resisting Cement.—As the result of considerable research, Messrs. J. H. Sankey and Son, Limited, Ilford, Essex, have evolved a cement which is stated to be entirely resistant to all acids, hot or cold, with the one exception of hydrofluoric acid. This cement, according to a leaflet sent to us, trowels easily, sets stone-hard within 12 hours of application, and is unaffected by temperatures up to 1,200 deg. C.

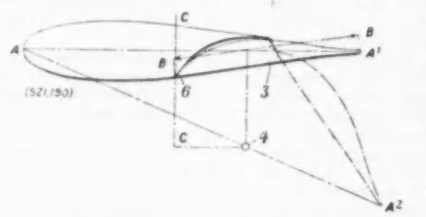
"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification drawings is stated in each case; where none is mentioned, the Specification is not illustrated.
Where inventions are communicated from abroad, the names, etc., of the communicators are given in italics.
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.
The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.
Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

AERONAUTICS.

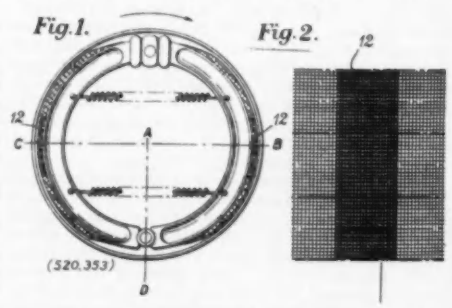
521,190. Wing Flap. Blackburn Aircraft, Limited, of Brough, and H. J. Stieger, of Brough. (6 *Figs.*) September 21, 1938.—The flap is designed to require small operating forces, and to be free from flutter. The fixed wing is symmetrical about a chord-line A-A^1. At the rear of the wing is an overhanging trailing part, the underside of which is concave. The wing is completed by a flap 3 of plano-convex section with, preferably, a slight reflex curvature of its upper surface towards its trailing edge. The chord dimension of the flap is B-B. The flap 3 is moved about a real or imaginary hinge axis 4. This axis is located about one-third of the flap chord to the rear of a plane C-C, which is perpendicular to the chord A-A^1 and passes through the nose of the flap 3 when neutral, as shown in full lines. The axis 4 is a slightly greater distance below the chord A-A^1. The trailing part of the wing extends as far to the rear as the



axis 4, and its underside curvature is such that, as the flap 3 is swung back, a divergent slot is progressively opened between the wing and the flap. This slot is of maximum breadth of opening (approximately 0·02 to 0·03 of the chord) when the flap is in its rearmost practical position. In the neutral position the nose of the flap contacts with the fixed wing at 6, thus closing the slot. The relationship between the wing chord, flap chord, location of the axis 4, and scope of movement of the flap, is further defined by the line A-A^2, which is drawn from the leading edge of the wing to the trailing edge of the flap fully extended, and which intersects the axis 4. The result of the relative dimensions is that the flap moves from neutral without any aerodynamic discontinuity from the fixed wing except inasmuch as a slot is opened which, rather than breaking up the airflow above and below the wing as a whole, tends to maintain it. Moreover, the chord of the whole wing is in effect increased as the flap moves back affording greater area. The location of the axis 4 is such that the resultant air load on the flap in all positions is somewhat to the rear of it, to stabilise the flap, by virtue of the slightly reflex and prolonged trailing edge.—(*Accepted May* 15, 1940.)

MOTOR VEHICLES.

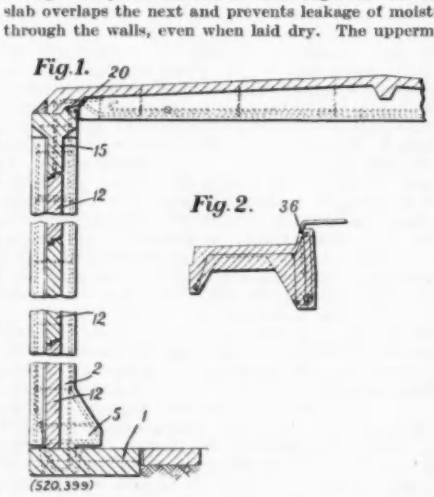
520,353. Brake Lining. British Belting and Asbestos, Limited, of London, and J. C. Fenton, of London. (4 *Figs.*) October 19, 1938.—From the mechanics of brake shoes in internal expanding brakes it is known that the pressure



over the lining is distributed according to a sine law, with the line of maximum pressure C B perpendicular to a radial line A D passing from the centre of the drum through the fulcrum of the brake shoe. The area of greatest pressure lies at and immediately on each side of the line C B and this is also the area where greatest wear occurs. The area of greatest torque reaction, however, is at the leading edge of the shoe, the torque-reaction at any given point being proportional to the distance from the fulcrum. The invention is a lining which contains warp and weft threads of asbestos, which are given a local reinforcement 12 by introducing over that area additional metallic threads running in one direction only—either the warp or the weft, and the metallic reinforcing threads may even replace the plain threads in one direction at this particular area. The fabric is woven in a band (see Fig. 2), from which the linings are cut, the width being equal to the length of the lining. Thus the warp threads of the band run transversely to the lining and reinforcing warp threads are added at the area 12. By this method, moreover, a plain weft thread is employed which runs lengthwise of the finished linings. The new linings have increased durability at the area of greatest wear and additional frictional qualities at the area of greatest torque-reaction, thus compensating for any loss in frictional characteristics due to the reinforcing threads over the remainder of the lining. Since the area adjacent to the leading edge is not subjected to the same degree of wear as the area of greatest pressure, the omission of reinforcing threads, which leads to the increase in coefficient of friction at the leading edge, has no detrimental results on the durability of the lining as a whole. (*Accepted April* 22, 1940.)

MISCELLANEOUS.

520,399. Concrete Trenches. Stent Precast Concrete, Limited, of Westminster, and D. H. Stent, of Westminster. (6 *Figs.*) October 20, 1938.—In the floor of the trenches at intervals are foundation slabs 1 for vertical reinforced-concrete posts 2. The remainder of the floor is concreted. Each foundation slab has a tapered recess, into which fits a spigot on the lower end of the post. A foot 5 bears on the foundation slab 1. The posts are of H-section, the width of the grooves being equal to the thickness of the slabs 12 which line the trench. These slabs are of pressed concrete, produced in hydraulic presses under high pressure, and are extremely dense and strong. They are rebated at their edges so that each slab overlaps the next and prevents leakage of moisture through the walls, even when laid dry. The uppermost



side slab forms a wall beam 15 having an enlarged upper portion, which is the same width as the post 2. This enlarged portion has shoulders on the outside and on the inside both of which seat on the top of the post 2. The upper surface of the beam 15 is generally flat with a projection 20 on the inside. The trench is covered by a roof formed of preformed roof slabs placed side by side and supported from the wall beams 15. The roof slabs are of shallow inverted U-section and are slightly arched longitudinally. At each end the slabs are hooked to fit over the top edge of the wall beams 15. A lip runs along each side of the roof slab, so that when two slabs are placed side by side, a channel is formed into which grout is run to bond them together. Towards each end of the slab, a vertical groove intersects the lip so that when the roof slabs are in position, grouting holes are formed by the grooves over the top edges of the side wall. The grout runs down these holes and finds its way between the roof slab and the side slab supporting it, and provides a good bedding which allows for slight inaccuracies in manufacture or laying of the slabs. The posts and the wall slabs have projecting reinforcing rods which project into the grouting holes and are covered with the grout to form a bond between the side walls and the roof. The end roofing slabs of one run of trench at an intersection are formed with a projecting rib 36 along one edge (see Fig. 2) of thickness equal to that of a side slab to receive the hooked ends of the roof slabs of the cross run. (*Accepted April* 23, 1940.)